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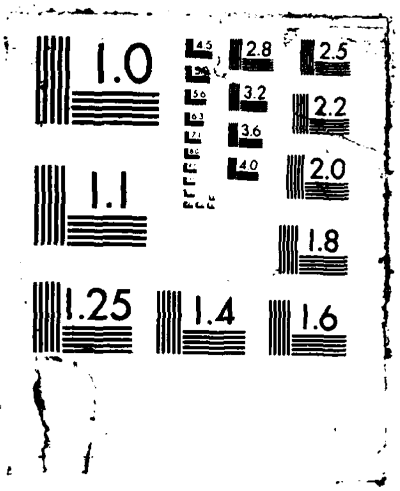
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ADVANCED HUMAN FACTORS ENGINEERING TOOL TECHNOLOGIES

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This report presents the results of a study to identify the human factors engineering (HFE) technologies or tools presently used, and projected for use by HFE specialists. Both traditional and advanced tools were candidates for inclusion in the report, although the emphasis of the study was on advanced computer applications. Human factors practitioners representing the government, the military, academe and private industry were surveyed to identify those tools most frequently used or viewed as most important for conducting human factors engineering related work. If advanced tool capabilities did not meet existing job requirements, the specialists identified the types of tools they would like to see developed to fill the existing technology gaps. The advanced tools were categorized using an eight point classification scheme, which included the phase(s) of the material acquisition process in which the tools' application would be most

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appropriate. All of the tools were prioritized to facilitate tool selection, and entered into a database to accommodate future revisions. The survey resulted in the identification of 113 advanced human factors engineering tools.

SUMMARY

The following report presents the results of a Small Business Innovative Research Phase I award to identify the advanced human factors engineering (HFE) tools presently used, and projected for use, within the military and civilian sectors, along with a categorization of these tools based upon their utility in facilitating human factors engineering research during the phases of the materiel acquisition process (MAP).

The approach taken began with a search of the literature to identify both traditional and manual tools. Next, human factors specialists were surveyed to identify the HFE tools which are considered most important, or that are most frequently used in the day-to-day conduct of their job. The survey was geared toward both aviation specific and non-aviation related tools. The survey also attempted to seek out those conditions under which the tools are used, including the phases of the materiel acquisition process. Both conceptual tools and tools in the prototype phase of development were considered candidates for inclusion. The advanced tools were next categorized using an eight point classification scheme which included the phase of the MAP in which the tools application would be most appropriate, together with the tools activity, class, type, role, application, status and cost. Decision criteria were then developed as the basis for the tradeoff process to aid in tool selection.

To facilitate the inclusion of new technologies as they become available, and to aid in the search and retrieval of a tool's capabilities, the advanced tools were entered into a data base. Military HFE specialists were resurveyed to gain insights to the adaptability of the tools in meeting the Army's Test and Evaluation (T&E) and Research and Development (R&D) needs. The survey resulted in the identification of 113 advanced tools, 88 of which were determined to contain sufficient information to be included in the data base. The results of this study suggest that, although a large number of tools presently exist that are capable of helping HF specialists practice their profession, the human factors engineering community would welcome additional tools, especially those configured to run on a desk top microcomputer. Future emphasis in tool development should focus on expert systems, human factors data base compendiums, workload prediction tools, and automated task analysis programs.

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1.0 INTRODUCTION

1.1 Preface

In support of the Advanced Human Engineering Tools Workplan dated July 28, 1986, Carlow Associates Incorporated submits the following report in fulfillment of Contract DAAA15-86-C-0064. This contract was awarded in response to an SBIR solicitation, with this report satisfying the final task of the exploratory development effort as defined under the requirements of the Phase I SBIR program. The work described in this report was performed for the U.S. Army Human Engineering Laboratory (USAHEL), at Aberdeen Proving Ground, Maryland. The technical monitor for this contract was Ms. Helen M. Nicewonger of the Aviation and Air Defense Directorate. The report which follows represents the culmination of the final task, and presents our findings and recommendations surrounding the availability and use of advanced human factors engineering (HFE) tools by HFE researchers and practitioners within the academic, industrial, and military settings.

1.2 Scope

With the speed at which information technologies are developing and being integrated into today's systems, a corollary pace will be required of HFE researchers if users of the information are to be considered. Fast turnaround is a euphemism as important in science and engineering as it is in the restaurant business. While good science and good human factors cannot be rushed, a continued reliance on the tools of the past will most likely bring despair to the hearts of those relying on HF engineers for fast answers. Recognizing the limitations of traditional technologies or tools for satisfying the analysis, design and evaluation demands associated with today's advanced systems, the Army contracted Carlow Associates to identify those advanced tools that are presently available and in use in laboratories and field settings throughout the HFE arena. The report which follows presents to the military community the available HFE advanced research tools which may enable more expeditious and less costly development evaluation of the soldier-machine interface.

The research conducted during the course of this contract is intended to support the initiatives of the Manpower and Personnel Integration (MANPRINT) program. To ensure that the studies conducted during the Phase I effort are of maximum utility to the MANPRINT program, a scope-of-work which compliments work that has already been performed by Carlow Associates during FY 1986 MANPRINT initiatives was proposed.

In an effort to develop a standard MANPRINT process based on USAHEL human factors engineering analysis (HFEA) approach conducted for FMC under its internal research and development (IR&D) program, Carlow Associates identified traditional tools applicable to each of the MANPRINT domains. The results of that task yielded the identification of over 100 models,

methods and data bases used in support of the MANPRINT process. The tools identified encompassed the domains of HFE; manpower, personnel and training (MPT); systems safety (SS); and health hazard assessment (HHA). To prevent duplication of effort, the present task concentrated solely on HFE tools; generic methods and techniques which have not been proceduralized or modeled, such as task analysis and operational sequence diagrams, were excluded from the survey, as were data base management systems and dynamic simulators. Similarly, the MP&T, SS, and HHA domains remained out-of-scope.

1.3 Background

It was the outbreak of the second World War which established the impetus for recognizing human factors engineering as a separate discipline within the field of psychology. The war produced systems of such complexity that the common sense approach to design was no longer adequate for solving the many problems of human use introduced by the newly emerging technologies. In their efforts to match these modern machines to their human operators and maintainers, human factors researchers developed methods to collect and analyze the information needed for the solutions to these problems. Techniques were developed, or borrowed from other specialties, to assist these renaissance researchers in their quest for a better understanding of the factors which influence human performance. These techniques in turn relied on the use and creation of tools to match machines and tasks with the abilities of their human operators. Many of these early tools are still in use today. Anthropometers, task analysis techniques, motion picture cameras, sound pressure level meters, and the machinist's ruler are just a few of the many tools which are used by the human factors researcher.

It is a sophisticated skepticism and general mistrust of intuition which are largely responsible for the success of human factors engineering. During the war, this trait was responsible for rallying the "nonbelievers" into a mind-set that the design errors which were plaguing the military could be mitigated by the systematic application of behavioral principles. Today, HFE researchers are experiencing a resurgence in popularity heretofore unequalled. The advent of microelectronics has resulted in systems of increasing complexity. The automated weapon systems, integrated command and control systems, and "smart" systems of today are relying more on the cognitive skills of the human operators and less on the sensory/psychomotor skills which were required in the electromechanical systems during the second world war. It should come as no surprise, then, to learn that the HFE researchers and practitioners of today are being called upon with increasing frequency to apply their knowledge of cognitive psychology to the problems facing human users of technologically advanced systems.

Outside of the typical "mainstream" tools generally associated with human factors engineering, are those tools which do not readily elicit recognition due to their novelty or general lack of citation in the human factors literature. For example, SAMMIE, MAWADES, and

SIMWAM are several automated aids which have more recently been introduced. The application and utility of these alternative tools by HF engineers during the system design and development life cycle, however, have been largely unexplored. For the purpose of this report, these alternative or advanced tools are largely computer programs. Included herein are computer programs as diverse as the first man-machine simulation model, developed by Arthur Siegel and Jay Wolf back in 1969, to the conceptual Designers Associate expert system, which is presently under development at MacAulay-Brown Inc., in Dayton Ohio, funded through an Aerospace Medical Research Laboratory (AMRL) contract out of Wright Patterson Air Force Base.

1.4 Objectives

The primary objective of this contract was to identify the advanced tools presently in use by HFE practitioners within the military and civilian sectors, and to categorize these tools based upon their utility in facilitating human factors engineering research during the materiel acquisition process. This report constitutes the final product of the Phase I program, together with a data base which itself can be used as a tool in searching for information on a specific tool, or on the appropriateness of a tool for a given application.

The specific objectives during the exploratory development phase of this effort were to:

- Identify the advanced HFE tools which are presently used in laboratories and field settings within the military, private industrial, government and academic settings;
- Identify the capability of these tools in augmenting or replacing the more traditional tools typically associated with HFE research during system development;
- Identify those advanced HFE tools which are adaptable to military research needs; that is, tools that are effective and reliable, transportable (within the hardware compatibility context), and versatile enough to be utilized in a variety of settings;
- Identify stages of the materiel acquisition process to which the tool application is appropriate
- Identify decision criteria that can be employed in a trade-off matirx to rate the overall desirability of a tool;
- Recommend, based on the foregoing steps, viable additions to the Army HFE community's standard tool set;

The technical approach to meet these objectives is described in Section 1.5 of this report.

1.5 Overview

The initial step involved the development of a work plan geared to the objectives of the task assignment. The work plan which resulted involved the conduct of five tasks: (a) review of the literature, (b) survey of HFE professionals and manufacturers, (c) development of a tool taxonomy, (d) follow-up survey, and (e) development of cost-effectiveness trade-off criteria. A flow chart depicting the general flow of review activities is presented in Figure 1.

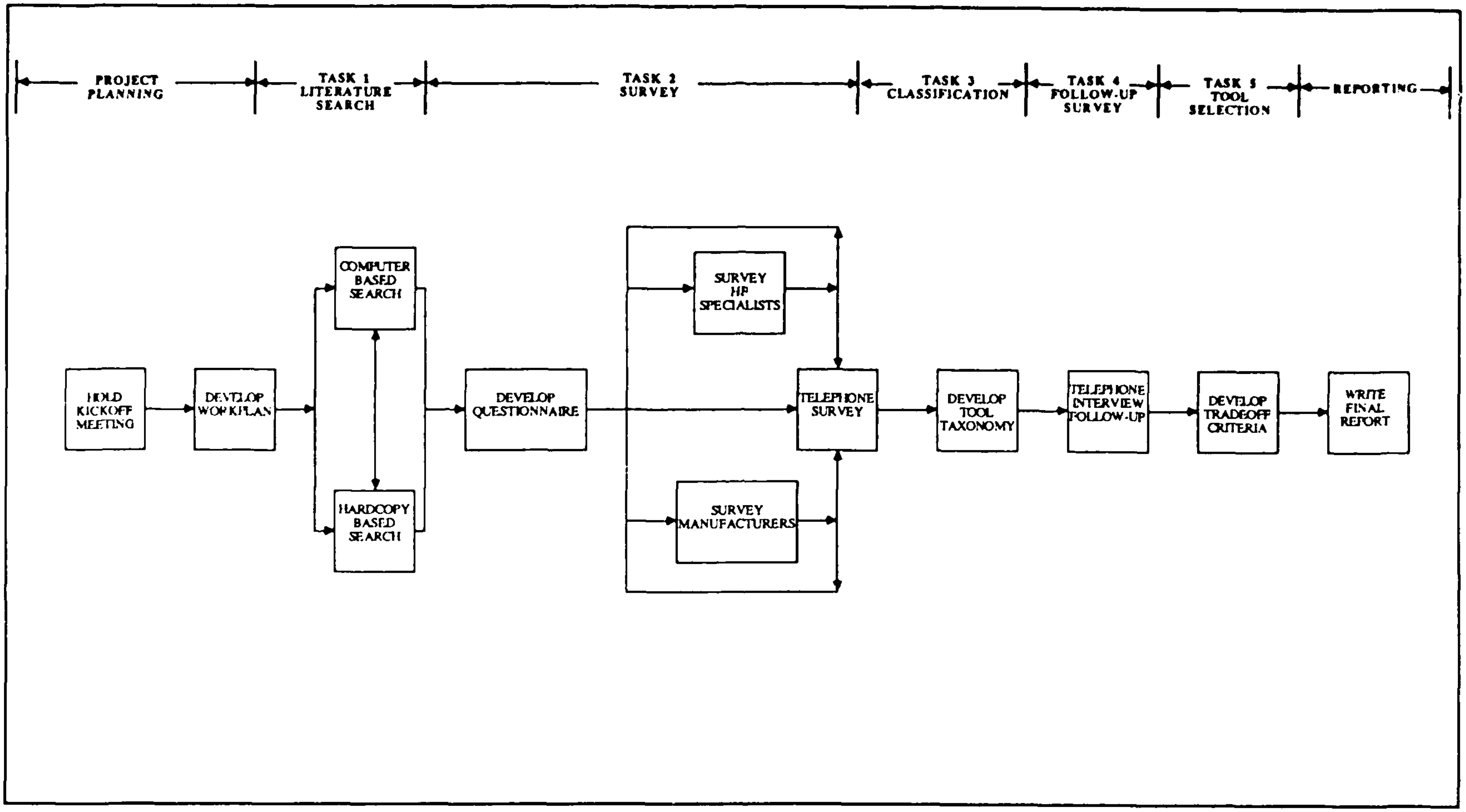

Figure 1. Task Flow Relationships of the Advanced HFE Tool Survey

The first task involved the conduct of a literature search. This review served as the foundation for subsequent tasks. The literature review focused on advanced, software oriented tools, as well as on traditional human factors tools (e.g., photometers), although the emphasis was on advanced tools. Both automated and manual searches were conducted to ensure as comprehensive a review as possible. The specific approach taken to identify the tools currently in use by HFE specialists is described in Section 2.1 of this report.

The second task entailed a survey of human factors professionals. Practitioners from academe, the government, industry, and the military were asked to participate in a questionnaire survey designed to capture their knowledge regarding the use of HFE tools. The purpose of the survey was to identify the traditional and advanced tools which are presently used in laboratories and field settings throughout the HFE community, and to identify the capabilities of the advanced tools in augmenting the more traditional tools typically associated with human factors research. The methodology used to conduct the surveys, is described in Section 2.2. The questionnaire used to solicit information regarding tool use has been provided in Appendix E. A complete list of survey participants can be found in Appendix F.

The advanced tools identified during the preceding tasks were taxonomized during Task 3. The purpose of this task was to organize the identified tools in a manner conducive to identification of the features relevant to their state of development and utility. To facilitate the retrieval of information, all tools were entered into a data base. The tool taxonomy used in development of the data base consists of 20 different fields used to describe the tools capabilities and limitations. Included in the taxonomy is a description of the tool, and an eight point classification scheme. Tools which can be used for aviation related research have been appropriately identified. A more thorough description of the classification is provided in Section 2.3. Appendix A contains a hard copy printout of the data base. A user's guide to facilitate employment of the data base is presented in Appendix D. The classification of the individual tools has been printed out separately, and is included in Appendix B, with Appendix c presenting an assessment of the costs associated with a tool's use.

In Task 4, a follow-up telephone survey was initiated. The purpose of this survey was to solicit clarifying information from the earlier respondents, and to query military users regarding the types of advanced tools they would like to see developed. Information was also solicited on the trade-off criteria to be applied in Task 5 to facilitate the tool selection process.

In the fifth and final task, performance trade-off criteria were applied to each advanced tool listed in the data base. The objective of this task was to identify the most cost effective tools that are adaptable to military research needs. The results of this trade-off process are presented in Section 2.5.

2.0 APPROACH

2.1 Task 1 - Literature Review

2.1.1 OBJECTIVE

The objective of Task 1, Literature Review, was to identify the traditional and advanced human factors tools that are presently in use by HFE practitioners. Since the intent of this contract was to identify the advanced HFE tools that are currently available, the use of traditional tools was relegated to a secondary role. For the purpose of this study, traditional tools are defined as instruments or techniques which essentially require manual data entry and/or manipulation (e.g., machinist's ruler, time line analysis, function allocation and sound pressure level meter). Advanced tools are computer based applications (e.g., man-machine simulation models).

As previously stated in Section 1.2, the research conducted during the course of this contract was intended to support the initiatives of the MANPRINT process. Since earlier work had been performed for MANPRINT to identify models and data bases that could be used as tools within the areas of MPT, SS, and HHA, these tools and domain areas were excluded from review. Also excluded from the definition of tools are generic methods and techniques which have not been proceduralized or modeled (e.g., link analysis, function analysis). The literature survey, therefore, focused almost exclusively on computer software which would fall under the aegis of HFE.

2.1.2 METHOD

The initial step toward HFE tool identification involved a review of existing in-house documentation. A survey of Carlow Associates library resulted in the identification of several technical reports and journal articles which discussed tool usage. References in these resources served as a stepping stone to a more advanced search of local university libraries. The school libraries that were accessed in this search included:

- George Mason University
- George Washington University
- The American University
- Catholic University
- Virginia Polytechnic Institute and State University.

Perusal of the documents gathered during the manual data collection method indicated that a more rigorous search of the HFE literature would be required. A subsequent automated search was initiated of the human engineering literature pertinent to available HFE technologies. Lockheed's online DIALOG Information Retrieval Service was selected, serving as a repository for over 170 different data bases. Of the data bases searched, six proved especially relevant, providing worldwide coverage of the journal literature, publications of professional societies, periodicals,

papers from conference proceedings, as well as selected government reports and articles. These data bases included:

- NTIS
- INSPEC
- SCISEARCH
- COMPENDEX
- PSYCHINFO
- Engineering Meetings.

The search was limited primarily to the psychological, engineering and computer science literature. Topic areas included, but were not limited to, the following:

- Human Factors Engineering
- Engineering Psychology
- Tools
- Instruments
- Technologies
- Devices
- Man/Machine Interface
- Soldier/Machine Interface
- User/Computer Interface
- Research
- Development
- Test
- Evaluation.

Document titles and/or abstracts were requested on-line, and all promising sources were ordered. When the literature arrived, it was examined for data relevant to the scope of the review effort.

2.1.3 RESULTS

Although the search resulted in literally hundreds of documents, a core of 71 references were found to be most relevant. These source documents have been included in the Bibliography at the end of this report, and may be consulted directly by the reader requiring further information or clarification on a particular tool.

2.2 Task 2 - Survey

2.2.1 OBJECTIVE

Due to the speed of recent technological advances, and the degree to which the effects may be reflected in the design and use of the man/machine interface, gaps in the knowledge base were expected in the published literature. For this reason, a separate survey was initiated to compliment

the literature review. The objective of the tool survey was to identify those tools that are most frequently utilized by HFE engineers in the day-to-day conduct of their jobs, together with any ongoing tool development efforts.

2.2.2 METHOD

A questionnaire consisting of 16 tool related questions was mailed to 283 human factors practitioners across the United States, together with a self addressed stamped envelope. Names for the survey participants were selected primarily from the May 1986 Directory of Researchers for Human Research and Development Projects. This publication is a Defense Technical Information Center (DTIC) document produced by the Manpower and Training Research Information System (MATRIS) office. The document provides a list of individuals who perform and/or manage people-related research and development projects for the Department of Defense (DoD). A secondary source for names was the Human Factors Society 1986 Directory and Yearbook. The Directory served as the primary source of names for practitioners specializing in aviation psychology and aviation related work. A survey of tool manufacturers was also conducted in parallel to the HFE practitioner's survey. The companies and individuals associated with tool development identified during the literature search served as the source for this phase of the survey. The telephone was used throughout this task, both as an initiator and expeditor of information retrieval.

The 1986 Human Factors Society convention held in Dayton, Ohio served as another source of survey participants. Approximately 100 questionnaires were distributed to the convention attendees. In an attempt to attract the largest number of participants, the HFE Tools questionnaire was configured into a data base format, and set up in Carlow Associates booth in the exhibitor's hall of the convention center. A computerized slide show accompanied the automated questionnaire, and introduced potential participants to the purpose of the questionnaire. The automated questionnaire served as the source for 25 responses.

2.2.3 RESULTS

Of the 283 questionnaires distributed through the mail, a total of 104 were completed, yielding a 37% rate of return. The people who participated in the study, along with their respective company or place of business is presented in Appendix F.

Of the responses, 71% indicated that they had been involved in the development of human factors tools. The responses were equally split as to those who had developed traditional tools and those who played a role in the development of advanced tools. Traditional tools were found to be favored nearly 2-to-1 over advanced tools. The main reason cited for this preference was cost and availability, although job requirements played a rather significant role. If an HFE specialist's job did not require the use of advanced technologies, then reliance on the more traditional tools would be expected. Nonetheless, many respondents expressed an interest in advanced tools. A general

lack of information concerning what advanced tools are available, however, was cited as a major reason for their disuse.

Forty-six percent of those responding have either developed tools, or regularly use tools, to do aviation related HFE work. The most frequently cited traditional tool used within the aviation community was task analysis, with sensory and environmental measurement devices such as photometers, spectroradiometers, and sound pressure level meters coming in a close second. Function analysis tied for third place with HFE data compendiums, which included standards, handbooks, and guidelines, and SWAT, a workload evaluation rating scale. The advanced tools used most frequently for aviation related work were task modeling simulation tools, with SAINT being the most popular. A dissatisfaction was found to exist with the capabilities offered by existing tools, with task analysis being the major protagonist. The problem with task analysis lies in its labor intensiveness. Since task analysis is used as the foundation for the rest of the HFE analysis, a successful task analysis depends on a thorough description of the tasks and the task requirements. Task requirements are also necessary early in the design process, for representative mission, mission scenarios and tactical conditions. Often, specific man-machine interactions are not available until late in the design process, necessitating frequent, and often extensive updating. Those practitioners who use task analysis would like to see the technique automated to facilitate the initial entry and updating of task information. Other tools they would like to see developed are a better workload technique and new, or improved, pilot performance measures. The ideal tool would be a computerized workload model, and would include objective measures of cognitive workload together with physiological performance predictors; the tool should be integrated into a time line, and produce quantitative output.

Looking at the tools used outside of the aviation specialty, those traditional tools used most frequently or viewed as most important in the performance of HFE related work were sensory and environmental measurement devices such as those found in the HFE T&E Tool Kit. The tools presently included in this kit, along with those recommended for use are presented in Table 1 in Section 2.3.3. Task analysis placed second among the traditional tools, with HFE oriented handbooks, guidelines and standards tying with questionnaires for third place. The most frequently cited advanced tools were microcomputer based applications, including word processing, statistical analysis, data base management, project planning, and graphics/design software packages. The SAINT and MicroSAINT task modeling simulation tools came in second. A narrow majority (51%) of those responding said they were satisfied with the existing capabilities of the tools available. The remaining respondents indicated that the requirements of their jobs were not satisfied by the features available for the tools that they regularly used, and thought improvements were in order. As with aviation tools, the most frequently cited problem tool was task analysis, with 61% of the respondents stating a need for improvement. An automated

procedure that could be easily modified to accommodate the demands of the iterative design process would be universally welcomed. The improvement cited most frequently which could be made to the advanced tools SAINT and MicroSAINT is the addition of a graphics interface. A direct manipulation interface, similar to that found on the Apple Macintosh computer, would immensely facilitate data entry.

The survey identified a consensus within the HFE community of the need for new, more advanced tools. Over 88% of those responding felt that more computerized tools would be a boon to the HFE profession. The two most frequently requested tools were for data bases containing detailed design and human performance information (i.e., HFE engineering standards, principles, performance criteria, and guidelines) and computerized workload prediction tools. The next most frequently requested tools included expert systems, automated task analysis programs, and computer aided design (CAD) programs. When asked if they would be interested in seeing more advanced tools developed for use on the desk top microcomputer, 82% responded positively. Again, HFE data base compendiums containing performance criteria, design criteria and guidelines were the tools of choice. Automated task analysis programs integrated with human performance data was the second most popular tool of choice, with workstation CAD, anthropometric man-model programs and user/computer interface (UCI) rapid prototyping software all tied for third place.

The typical response when asked what existing main frame or minicomputer tools should be modified for use on a microcomputer was "all of them." When asked to be more specific, the tools cited most frequently were SAINT (which has already been adapted to the microcomputer as MicroSAINT, by Micro Analysis and Design, Inc., under a contract with the Army Medical Research and Development Command) and HOS IV, followed by the development of micro-based, HFE oriented expert systems (ES). The remaining tools requested for modification included:

- CAFES (with a "Macintosh like" interface)
- SAMMIE (for the Apple Macintosh)
- MIST (an MP&T tool)
- GENSAW
- Designer's Associate
- BEMOD
- MicroSAINT (with a direct manipulation interface)
- CAR.

These tools are fully described in Appendix A.

2.3 Task 3 - Tool Taxonomy

2.3.1 OBJECTIVE

The objective of the HFE tools taxonomy task was to develop an organizational framework for the tools identified during the literature review and survey, and to provide a method by which important features relevant to a tool's state of development and utility could be quickly accessed.

2.3.2 METHOD

The approach taken to meet the objectives of this task was the creation of an advanced tools data base management system (DBMS). Such a system was deemed necessary since an objective was to provide an efficient means of searching for and retrieving information. A corollary benefit of entering the results of the tools survey into a structured DBMS is that it provides a mechanism for easy expansion. Updating the final product as new tools hit the market, or as additional information is received, will be much simpler, and therefore more likely to be done. Additionally, users will be more likely to take advantage of the data base if it represents an up-to-date reflection of the availability of state-of-the-art HFE tools.

The system selected to create the data base was the Double Helix program by Odesta Corporation. The data base, as configured, runs on a Macintosh Plus microcomputer and requires 512 Kb of RAM and two 800 Kb disk drives. The taxonomy used in defining the advanced tools capabilities and limitations consists of 20 discrete fields of information. A description of these fields follows:

Tool Name - The full name for the tool along with the more familiar acronym or abbreviation, where applicable.

Record No. - A unique numeric identifier used to facilitate the retrieval of a specific tool from the data base.

Description - A narrative description of the tool synthesized from information obtained during the literature review, practitioner survey, and follow-up survey.

Input Requirements - Those features which must be known or identified before the tool can be used effectively.

Output Requirements - The expected results from a successful application of the tool.

Resource Requirements - The hardware and/or software required in order to use the tool.

Advantages - Strengths or positive features of a tool which facilitate its application or maximize its utility.

Disadvantages - Drawbacks or negative aspects of a tool which thwart its potential.

MAP Phase - Phase(s) of the materiel acquisition process (MAP) in which the tool can be used or is typically used to derive its maximum effectiveness. These phases include:

- Preconceptual (PRE-CON)
- Concept Exploration (CON)

- Demonstration and Validation (D&V)
- Full Scale Development (FSD)
- Production and Deployment (P&D)
- Product Improvement (PI).

Activity - The human factors engineering activity area under which the tool falls. Activity areas include:

- Design
- Analysis
- Test and Evaluation (T&E).

Tool Type - The application area under which the tool falls, in other words, what the tool is. The different kinds or types of tools include:

- CAD
- Functional model
- Task model
- Task model, workload
- Task model, time line
- Task model, performance
- Data access
- Workspace model
- Graphic
- Family of tools
- Rating scale
- Reliability model
- Logistics model
- Man model
- Man model, graphic
- Man model, CAD
- Man model, animation
- Man model, crash simulation
- Man model, simulation
- Data base
- Information flow model
- Information model
- Rapid prototyping
- Expert system
- User Interface Management System (UIMS)

Tool Class - The specific HFE classification under its general area of application; that is, what the tool does. Tool class may be viewed as a subset of tool type, and generally includes a combination of the classes listed below:

- Panel design/evaluation
- Performance analysis
- Workload analysis/evaluation
- T&E
- Maintenance analysis
- UCI design
- Comparability analysis
- Display evaluation
- Functional analysis
- Front end analysis (FEA)
- Task modeling
- Workstation design
- Procedures
- Reach/vision analysis/envelope
- Facility design
- Task analysis
- Procedures design
- Function allocation

- Crew station design
- Simulation
- Force/torque
- Strength
- Management
- Training analysis
- Workspace layout
- Task allocation
- Life support
- Robotics, reach
- Robotics

Tool Role - Presents examples of how the tool has been used in the past or how it can be used within a given HFE context. Role should be considered a combination of tool type and class.

Application - The tools orientation, that is, its role as being either a traditional tool with a manual, generic or data bent, or an advanced tool running on a main frame, minicomputer, or desk top microcomputer. For this phase of the contract, all tools included in the DBMS are advanced applications. This field has been added in anticipation of updating the system to include traditional HFE tools (e.g., hand held and generic proceduralized tools), and eventually tools which fall under other MANPRINT disciplines (i.e., HHA, MP&T, SS).

Status - Refers to the tools accessibility. Under status, the tool is classified as:

- Conceptual: not presently available for application.
- Prototype: available but does not include all planned features, or may not have been fully verified and/or validated (e.g., tools in the beta stage of testing).
- Operational: fully developed and available.

Cost - The absolute cost of the tool has been included if the information was available.

Aviation Related - Tools used specifically for aviation related work or which can be applied to aviation type problems have been identified as such.

Source - Identifies the tool developer, manufacturer or source from which the tool can be obtained.

References - Cites the reference materiel or personal conversations used in compiling information on the tool. Complete references can be found in the reports bibliography.

Comments - A catchall field designed to capture information which does not belong in any of the other fields. For example, proprietary tools are noted within this field.

Menus have been added to the data base to allow the user to quickly search those areas considered to be of primary importance. These areas include the six phases of the materiel acquisition process, the three HFE activity areas, and those tools related to aviation. The remaining categorization fields and categorization levels can all be used, either singularly or in combination, to query a specific area of interest associated with advanced tool use. For example, all man model or workspace layout related tools can be identified quickly by using the Query function for Tool Type and Tool Class, respectively.

2.3.3 RESULTS

Phase I efforts have resulted in the identification and documentation of 113 advanced human factors engineering tools, 88 of which were determined to have enough descriptive information to be included in the data base. A narrative summary which describes the purpose of each tool, along with all other related information which is found in the data base has been included in Appendix A. Given the time and money constraints imposed on the contract, every effort was made to ensure that the descriptive information contained in the data fields under each tool was as exhaustive as possible. At times however, no information could be found on some of these areas. In such circumstances, the phrase "None Identified" appears in the data field. A complete listing of all the tools contained in the data base is presented in Table 1.

The traditional tools identified during the course of this contract have not been included in the data base. The most popular (i.e., widely used) and frequently cited traditional tools with application to Army T&E activities have been sorted into application areas, and identified along with the name of the tools manufacturer. This list of HFE tools are those recommended to be most advantageous in satisfying Army objectives. Their use and application will be fully described in a video tape training program under a different Army contract performed by Carlow Associates for TECOM. The complete list of traditional tools, along with their related accessories, can be found in Table 2.

Other advanced tools with HFE applicability were identified but do not appear in Appendix A, either because of limited information availability or because their existence became known too late in the course of the contract for inclusion in the data base. These tools are briefly summarized below.

- Available Motions Inventory (AMI) - A system for measuring human physical ability based on components of industrial manual tasks. The AMI consists of short cycle tasks measuring specific functional output.
- Operator Station Design System (OSDS) - A stand alone minicomputer based workstation used to design panel layouts, assess reach and vision envelopes, determine physical interference constraints and fit problems early in the design phase, and study design applications as a function of anthropometric and mission requirements. The system uses the PLAID and CAR programs, and relies on a data base which consists of Shuttle Transportation System orbiter crew compartment data, orbiter payload bay and remote manipulator data, and various anthropometric populations.
- Force Man - A 3-D man modeling program for computing force capabilities as a function of equipment mass, body position and gravitational force. The man model consists of 19 links and 17 joints.

- Lift Man - A man modeling program used to predict strength capabilities in a one-G environment.
- MTM Man - A man model program developed for the design of manual work stations. The spatial coordinates of torso and upper extremity joints are computed based on limb lengths, chair geometry, and a sequence of hand locations and orientations.
- BULGAR - A man model program that employs a 13 joint, 14 link model. The program calculates the location of body segments from anthropometric and joint angle data.
- TORQUEMAN - A man model program that computes the static forces and torques at 6 body joints. After entering joint angles, external force characteristics, and anthropometric variables, the program displays force vectors on a 2-D graphical man model.
- SAS - An animated man model program which uses 3-D anatomically correct human skeletons. The human figure movements are executed procedurally using a hierarchical organization of control programs. Tasks are broken down into sets of movement skills. Each skill is implemented by a programmed set of procedures which evoke a set of movement primitives. The program uses motor procedures for standing, broad jump and various stages of locomotion over level, unobstructed terrain.
- Business Filevision - A graphic information management system that integrates a filing system and drawing system with a report generator. Information can be represented in pictures, words or numbers. The program contains built-in statistical capability, and is capable of sorting and analyzing extensive data which is embedded within smart drawings. Can also be used as a rapid prototyping system to mock-up user-computer interfaces. (Telos Software)
- Enhanced Graphics Adapter - Generates graphical operational sequence diagrams. Government owned (Naval Ocean Systems Center).
- Network Management Tool - Organizes and arranges characteristics of task networks for structuring function flow block diagrams. (Boeing Aerospace)
- MAP - A PC based tool used to assess performance effectiveness based on subjective measures (Army Research Institute).

Some advanced tools were identified during the literature review for which no definitive information was available. Rather than dropping these tools entirely from the report, they were elected for inclusion in hopes that acknowledgment of their existence would in some way benefit readers who may be familiar with them. These tools include:

- Automated Sequence Plotter (ASP)
- MONTE
- Fourth Man

- Job Assessment Software System (JASS)
- Task-Time Multiplan
- Human Performance Modeling Language
- Integrated Ergonomics Model
- On-line Critical Incident Tool
- GREAT
- WINDEX
- Computerized WAM
- Computer Model of Body Motion

Table 1. Advanced Human Factors Engineering Tools

18	ADM (A Dialog Manager)
25	ASSET (Acquisition of Supportable Systems Evaluation Technology)
50	ATB Model
75	BEMOD (Behavior Modification)
51	BIOMAN
52	BUFORD
31	CADAM/ADAM (Anthropometric Design-Aided Mannequin) & EVE (Ergonomic Value
45	CADET (Computer Aided Design and Evaluation Techniques)
33	CAFES (Computer Aided Function Allocation Evaluation System)
37	CAFES-CAD (Computer Aided Function Allocation Evaluation System-Computer Aided
53	CALSPAN 3D CVS
13	CAPABLE (Controls And Panel Arrangement By Logical Evaluation)
21	CAPE (Computer Accommodated Percentage Evaluation)
77	CAPRA (Computer Aided Probabilistic Risk Assessment)
46	CAR (Crewstation Assessment of Reach)
28	CGE/BOEMAN (Crewstation Geometry Evaluation/Boeman)
47	CHESS (Crew Human Engineering Software System)
54	CINCI KID
55	COM-GEOM
6	COMBIMAN (Computerized Biomechanical Man-Model)
20	CORELAP (Computerized Relationship Layout Planning)
19	COUSIN (COoperative USer INterface)
1	CRAFT (Computerized Relative Allocation of Facilities)
68	CRAWL
56	CREW CHIEF
79	CUBITS (Criticality/Utilization/Bits of Information)
76	CVAS (Crewstation Vision Analysis System)
57	CYBERMAN
26	DAP (Display Analysis Program)
84	DART (Data Analysis and Retrieval Technique)
80	Designer's Associate
38	DMS (Data Management System)
58	ERGOMAN
23	ERGONOGRAPHY
73	ETAS (Essex Training Analysis System)
34	FAM (Functional Allocation Model)

Table 1. (cont'd.)

15	FLAIR (Functional Language Articulated Interactive Resource)
87	Function Allocation Decision Aid
67	GENSAW (Generic Systems Analyst Workstation)
88	GEOMOD (Geometric Modeling Tool)
59	Graphical Marionette
30	GRASP (Graphical Robot Applications Simulation Package)
3	HECAD (Human Engineering Computer-Aided Design)
29	HF-ROBOTEX (Human Factors-Robotics Expert System)
69	HIMS (Helicopter Inflight Monitoring System) II
36	HOS (Human Operator Simulator)
60	HSRI Models
74	ICAM (Interactive Control Assessment Methodology)
32	KADD (Knowledge Aided Display Design)
82	Knowledge-based HFE Document Preparation System
16	LAYGEN (LAYout GENerator)
39	MAWADES (Multi-man MAchine Work Area Design Evaluation System)
24	MENULAY
14	Micro SAINT (Micro-Systems Analysis of Integrated Networks of Tasks)
86	MOPSIE (Multiple Operator Parallel Systems Evaluation)
61	NUDES
8	ORACLE (Operators Research and Critical Link Evaluation)
43	OSDS (Operator Station Design System)
49	OWLES (Operator Workload Evaluation System)
44	PLAID (Panel Layout Automated Interactive Design)
81	POSIT
85	PROFILE
5	SAINT (Systems Analysis of Integrated Networks of Tasks) I&II
12	SAMMIE (System for Aiding Man-Machine Interaction Evaluation)
63	SFU Model
27	SIEGEL-WOLF
83	SIMKIT
62	SIMULA/PROMETHEUS
7	SIMWAM (Simulation for Workload Assessment and Modeling)
72	SLAM II (Simulation Language for Alternative Modeling)
71	SPRINGMAN
17	STELLA (Structural Thinking, Experimental Learning Laboratory with Animation)

Table 1. (cont'd.)

64	STICKMAN
48	SWAT (Subjective Workload Assessment Technique)
22	TASCO (Timebased Analysis of Significant Coordinated Operations)
78	TEMPUS
4	TEPPS (Technique for Establishing Personnel Performance Standards)
11	TLA-1 (TimeLine Analysis Program-Model 1)
9	TREES (Tree Structured Data)
65	TTI Models
10	TX-105 (Operator/Crew Workload Assessment Technique TX-105)
66	UCIN
35	WAM (Workload Assessment Model)
42	WOLAG (Workstation Layout Generator)
2	WOLAP (Workspace Optimization and Layout Planning)
41	WORG (Workspace ORGanizer)
40	WOSTAS (Workstation Assessor)
70	ZITA (Zero Input Tracking Analyzer)

Table 2. Recommended HFE T&E Tools and Accessories

Illumination and Brightness

Photometer, Model FC-200, Photo Research Corporation.
- Photometer and readout/control unit
- Probe
- Cosine-corrected receptor
- Attenuator slide
- Photogrid
- Zeroing slide

LiteMate/Spotmate, Model 500, Photo Research Corporation.
- LiteMate photometer
- SpotMate attachment
- Zeroing disk
- Cosine-corrected receptor
- Spare battery
- Carrying case
- MicroReader probe
- Fiber optics probe
- Extension tubes

Pritchard photometer, Model 1980EMX, Photo Research Corporation.
- Photometer and readout/control unit
- Optical head
- Standard lens
- Close-up lens
- Portable AC power supply
- 20 foot extension cable
- Pan/tilt head
- Carrying cases

Noise

Sound level meter, Model B&K 2209, Bruel & Kjaer.
- Octave filter set, Model B&K 1613, Bruel & Kjaer.

Sound level meter - Model B&K 2230, Bruel & Kjaer. Replacing B&K during phaseout.
- Octave filter set, Model B&K 1625, Bruel & Kjaer.

Tape recorder, Model B&K 7006, Bruel & Kjaer.
- FM unit, Model B&K ZM 0053, Bruel & Kjaer.
- Compander unit, Model B&K ZM 0054, Bruel & Kjaer.
- Digital frequency analyzer, Model B&K 2131, Bruel & Kjaer.
- Connector cable, Model B&K AO 0194 or AO 0264, Bruel & Kjaer.

Digital oscilloscope, Model 4094, Nicolet.

Related microphones and accessories
- 1/2 inch condenser microphone, Model B&K 4165, Bruel & Kjaer.
- 1/2 inch condenser microphone, Model B&K 4134, Bruel & Kjaer.
- 1/4 inch condenser microphone, B&K 4136, Model Bruel & Kjaer.
- Microphone extension cable, B&K AO 0027, Model Bruel & Kjaer.

Table 2. (cont'd.)

- 1/4 -1/2 inch microphone adaptor, Model B&K UA 0035, Bruel & Kjaer.
- Windscreen for 1/2 inch microphones, Model B&K UA 0237, Bruel & Kjaer.
- Pistonphone calibrator, Model B&K 4220, Bruel & Kjaer.
- Preamplifier for 1/2 inch microphones, Model B&K 2642, Bruel & Kjaer.
- Power supply for battery pre-amplifier operation, Model B&K 280, Bruel & Kjaer .
- Power supply for AC pre-amplifier operation, Model B&K 2810, Bruel & Kjaer.
- Extension rod, Model B&K UA 0196, Bruel & Kjaer.
- Connecting bar, Model B&K JP 0400, Bruel & Kjaer.
- Power supply, Model B&K ZG 0199, Bruel & Kjaer.
- DIN cable (7 core), Model B&K AQ 0035, Bruel & Kjaer.
- Battery pack, Model B&K ZG 0146, Bruel & Kjaer.
- 12 Volt automobile battery.
- Spare 3.15 amp fuses, Model B&K VF 0019, Bruel & Kjaer.
- Extra recording tape (1/4 inch), Model B&K QR 1003, Bruel & Kjaer.

<u>Force and Dimension</u>

Force Push-Pull Gauges, 2,5,50 lb., Chatillon.

Dial Torque Gauges, Models TG-80 and TG-160, Chatillon.
- Attachments
  - -- notched head
  - -- flat head
  - -- cone head
  - -- chisel head
  - -- hook
  - -- extension rod

Torque Wrenches - M.H.H. (via Mountz); used with standard square shaft socket tool attachments & adaptor.

Dial Calipers, Helios, Fowler.

Tape Measures, 12, 20, 100 ft., Starrett.

Protractor - Tractograph.

Digital weight scales, Model 751T, Sears.

<u>Atmospheric and Environment</u>

Digital Thermometer, Model 8502-50, Cole-Parmer.
- Rechargeable batteries.
- In-line charger/ AC adaptor.
- Immersible probe.
- Air temperature probe.
- Surface temperature probe.

Sling psychrometer, MSA or Taylor 1328A.

Aspirating psychrometer, Model PP-100 or CP-147, Psychro-Dyne.

Table 2. (cont'd.)

Wet bulb heat stress monitor, Model B&K 1219, Bruel & Kjaer.
- Transducer, Model B&K MM 0030 (3 each), Bruel & Kjaer.

Air velocity meter (hot wire anemometer), Model 441, Kurz.
- Battery charger.
- Probe with cable.

Air velocity meter (hot wire anemometer), Model W141-A, Weather Measure .
- Penlight batteries - eight 1.5 volt.
- Probe with cable.

Anthropometry

Anthropometer, Siber.

Sliding Caliper, Siber.

Spreading Caliper, Siber.

Goniometer, Model and Manufacturer not established.

Performance

Digital Timer, Model LC-MST, Cronus.

Event Counter, Perceptronics.

Video Tape System
- Camera, Model DXC-3000 (replacement for JVC G-71USJ), Sony.
- Recorder, Model VO-4800, Sony.
- Monitor, Model Sony PVM-8000, Sony.
- Connector cables.

Camera, Model 600 SE, Polaroid.
- Electronic flash unit, Vivitar.
- Light meter, Model Scout 2, Gossen.
- Lenses - as required; suggest, at the minimum, a wide angle lens.
- Film, as needed.

35 mm SLR camera - Pentax MX.
- Accessories as needed (see list for Polaroid 600 SE above).

Instant camera - Polaroid Spectra.
- Film - special Polaroid film made specifically for the Spectra.

Recording and Analysis

Audio Recorder, Model TMC-111 or TC-55, Sony.

Programmable Calculator, Model TI-59, Texas Instruments.
- Adaptor/ charger, Model AC9131.
- Changeable cards for statistical packages.

Table 2. (cont'd.)

Micro-computer system - Macintosh Plus and supporting software(specific features/ accessories can be tailored to particular requirements).

Maintenance and Support

Equipment cases, provided with basic equipment.

Tripods, Star D.

Tool kit.*

Digital multimeter. A variety of multimeters are available, both in analog and digital formats.

Battery Charger. Available with basic equipment.

Binoculars, Bushnell.

*Although a variety of standard kits are available "off-the-shelf", it is recommended that the contents of tool kits be assembled according to specific requirements, i.e., to support equipment actually in inventory. N.B. As new equipment is added, relevant support and maintenance tools should be acquired simultaneously.

2.4 Task 4 - Follow-up Survey

2.4.1 OBJECTIVE

A follow-up telephone survey was conducted of military HFE specialists regarding the types of advanced tools they would like to see developed, and to gain insights into the adaptability of the advanced tools in meeting the Army's R&D and T&E needs. A secondary objective of this task was to solicit additional information surrounding a tool's use. This was necessary due to the unavailability of information in the literature, or the omission of significant data from the responses to the questionnaires. The third and final objective was to obtain information from the practitioners who have used the tools on a regular basis to facilitate the tool trade-off process to be conducted in the fifth and final task.

2.4.2 METHOD

Forty-four HFE specialists associated with the U.S. Military participated in the survey, with 75% of these contacted to solicit their opinions on the use of advanced tools within the military. Telephone calls were made to interview the specialists using customized questionnaires tailored to the specific objectives of the interview session. For the most part, the questions related to trade-off criteria concerning the tools availability, accessibility, adaptability, utility, training requirements and mobility, and clarification of selected responses from the questionnaire. The telephone calls took place during the weeks of December 15, 1986 through January 12, 1987. For the most part, the respondents were anxious to talk about the tools and contributed significantly to the outcome of the survey. The military specialists contacted were associated with the following installations:

- Naval Ocean Systems Center
- Office of Naval Research
- Naval Training System Center
- Navy Personnel Research & Development Center
- WPAFB-Flight Dynamics Laboratory
- WPAFB-Aerospace Medical Research Laboratory
- U.S. Air Force Academy
- U.S. Army Aviation Center-Ft. Rucker
- TECOM
- HEL-WPAFB
- HEL-Aberdeen Proving Ground
- ARI-Alexandria
- ARI-Ft. Bliss
- ARI-Ft. Hood

In addition to the telephone survey, a day trip to the Naval Air Development Center in Warminster, PA, was coordinated in an effort to obtain information from several military experts regarding their use and application of automated HFE tools. At this time, information was obtained on the advanced tools CAR, CADET, POSIT, COMBIMAN, CREW CHIEF, TEMPUS, PLAID, SAMMIE, HOS, and BIOMAN.

2.4.3 RESULTS

Seventy-three percent of those military specialists surveyed would welcome the addition of new automated HFE tools. Eighteen percent were indifferent, and 9% firmly communicated that new tools were not necessary. The reasons given by those with negative responses were largely attributable to the glut in the existing inventory of advanced tools. Reasons given by military practitioners which typify the consensus of "No" responses include:

- "There is a need for more human factors engineers to apply the tools that are available."
- "I would like them to become more accurate and affordable."
- "I'm tired of seeing old tools being reinvented and passed off as new tools."

The most frequently requested advanced tool by military human factors engineers was for a computerized workload prediction tool. The ideal tool would integrate measures of cognitive workload with physiological performance predictors to yield objective measures of performance. The tool should be able to accurately predict workload across a wide spectrum of job assignments, have good face validity, and be accepted by engineers. The tool next most frequently requested was a generic expert system (ES). An expert system refers to a "type" of advanced tool which is based on a collection of techniques associated with artificial intelligence research that enables computers to assist people in analyzing problems and making decisions. Expert systems are computer based technologies that perform at, or near, the level of a human expert. Two systems specifically requested were an ES capable of sorting through voluminous amounts of HFE data to solve problems relating to system design, and a system that can be used to select the appropriate HFE tools and technologies that are available to the HFE practitioner given a mission objective while considering constraints on the design or development process.

The tool cited with the best potential for application on a desk top microcomputer was task analysis. An automated task analysis program capable of systematically grouping and rapidly sorting through a data base of tasks and subtasks requirements and interdependencies would be welcomed by HFE practitioners both within and outside the military. The development of such a tool would minimize the labor intensiveness involved in the constant updating of task information as it changes during the iterative system development process. The tools next most frequently requested by military human factors engineers for development on a microcomputer included HFE data base compendiums and UCI rapid prototyping software. Other popular choices included

CAD programs, anthropometric man models, and an automated operational sequence diagram (OSD) application.

When quered about what existing minicomputer or main frame tools should be modified to run on a microcomputer, the typical response was SAINT. As previously mentioned in Section 2.2.3, SAINT has already been adapted to run on IBM PC compatible machines under the name of MicroSAINT. The remaining tools identified include:

- BEMOD
- CAFES
- Designer's Associate
- SAMMIE
- GENSAW
- HOS IV
- MIST (an MP&T tool).

2.5 Task 5- Trade-off Criteria

2.5.1 OBJECTIVE

The objective of the fifth and final task was to recommend to the Army a set of advanced tools that could be used to facilitate HFE soldier-machine interface research based on the tools performance characteristics and requirements in meeting system objectives. A corollary objective was to base these considerations on cost, where possible, to determine if the anticipated gains in performance could be used to justify the cost of developing or procuring a new tool.

2.5.2 METHOD

The first step taken in selecting tools was identification of the trade-off criteria that would ultimately be used in classification of the tool. Literature on trade-off analysis was reviewed, particularly as applicable to software and large system design. Chubb (1987) was particularly helpful in the area of human performance modeling and simulation languages. DeGreene (1970) and Meister (1971) provided general advice on the process of conducting trade-off analyses. In order to keep the process as simple as possible, yet maintain the robustness necessary for a useful trade-off, the number of criteria had to be kept at a manageable level, yet at the same time remain pertinent. Ultimately, six trade-off factors were selected which were deemed relevant to the task. These criteria include the:

- Availability- of a tool to the general public. Tools were classified as being either company proprietary, and therefore unavailable for general use, or commercially available to the HFE market.
- Accessibility- of commercial tools. Tools were classified as a) conceptual in their state of development and therefore not available in the near future for application; b) in the

prototype stage of development, and therefore available, but lacking certain features, or not fully verified and/or validated; or c) operational, fully developed and available.

- Adaptability- of the software to other computers. Tools exhibiting good adaptability exist in multiple versions, and therefore are capable of running on more than one machine. Self-contained computing mechanisms exhibit good adaptability.
- Utility- worth, or value of a tool as judged by its ability to satisfy the requirements or capabilities identified as important by the questionnaire respondents.
- Training- required before the tool can be used, or how easily the tool is learned.
- Mobility- or portability of the hardware on which the software runs. Microcomputers which can be taken into the field were judged better than mainframes in meeting certain military objectives.

The next step involved in the trade-off was to weight the above criteria, and build a decision tree (Figure 3) around the importance assigned to the criteria on which the tools could be judged. The criterion assigned the most weight was encountered first in the tree, with the weights for the remaining criteria falling off the further one passed into the tree. The importance of the criteria is therefore reflected in the sequence in which they appear in the tree. A Tool Categorization Form was filled out for each tool in the data base to reflect the ability of the tool in satisfying the trade-off objectives. This form is presented in Figure 2. The results of the completed Tool Categorization Form were next transferred to the Trade-off Criteria Decision Tree Form, with the final destination node highlighted and the respective encircled tracking number noted in the box at the bottom of the page (See Figure 3).

After all of the tools were rated, a prioritization scheme was used which reflected the results of the application of the criteria. The procedure adapts a three tier approach to tool assessment, and results in classification of a tool by Category, Desirability Level, and Priority. The Advanced Tool Assessment Form used in prioritizing the tools is presented in Table 3.

Category I tools are operational tools that are commercially available for immediate implementation. Category II tools are also commercially available, but represent tools in the prototype or beta stage of development. Category III tools include both proprietary tools, and tools that will be commercially available but at the present time are conceptual in nature and have not yet been built. Tools that fall under the third category were not prioritized due to the lack of available information.

Tools were also classed according to their desirability level, as defined below:

- Level A - good adaptability and high utility
- Level B - good adaptability but low utility
- Level C - poor adaptability but high utility
- Level D - poor adaptability and low utility

Tool Name: ____________________

1. Availability

Proprietary ________ Commercial ________

2. Accessibility

Conceptual ________

Prototype ________

Operational ________

3. Adaptability

Poor ________

Good ________

4. Utility

Low ________

High ________

5. Training

Rigorous ________

Minimal ________

6. Mobility/ Portability

Poor ________

Good ________

Figure 2. Tool Categorization Form

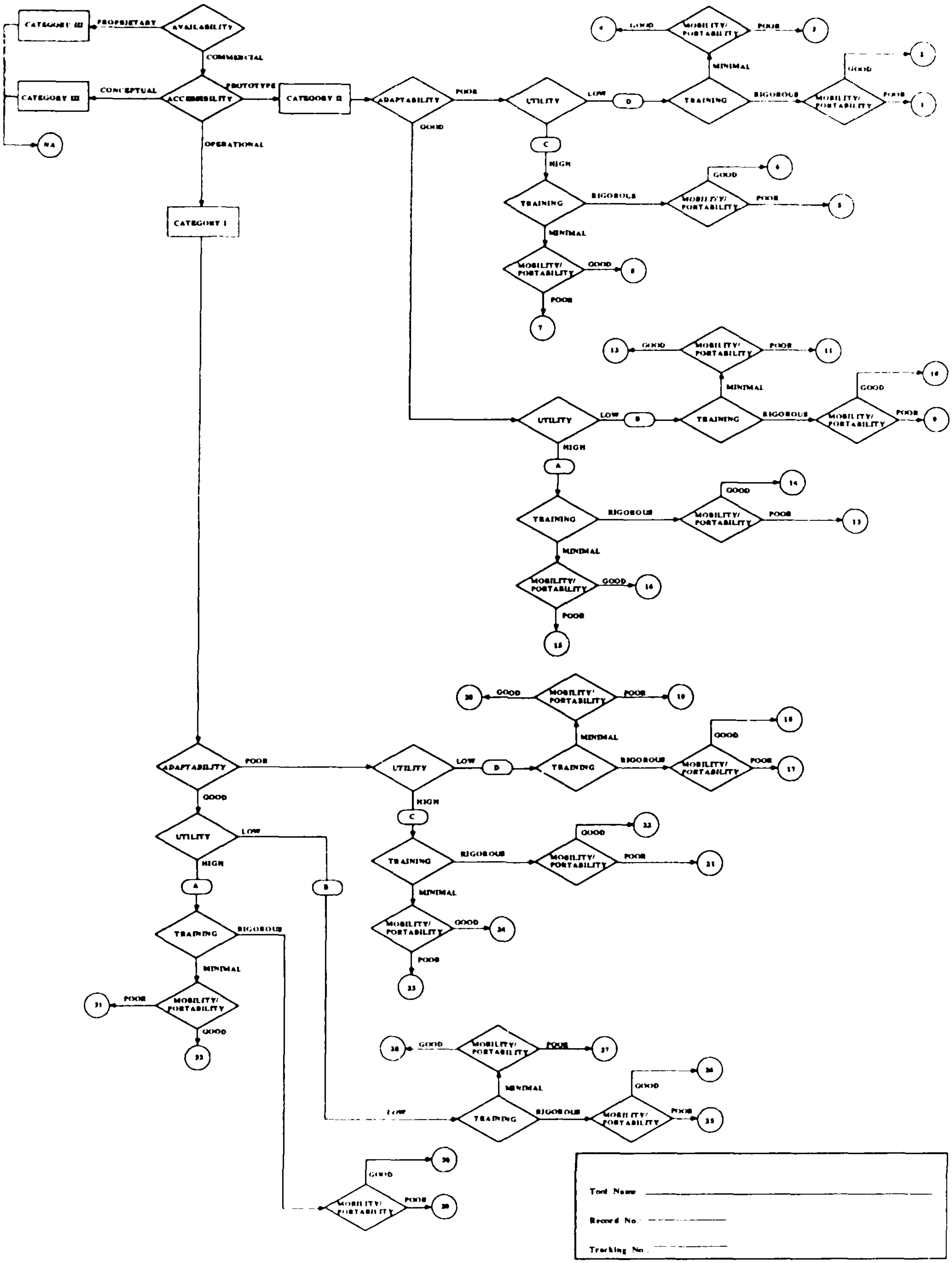

Figure 3. Tradeoff Criteria Decision Tree Form

Table 3. Advanced Tool Assessment Form

Tracking No.	Availability	Accessibility	Adaptability	Utility	Training	Mobility	Cat	Level	Priority
	Proprietary Commercial	NA Conceptual	NA NA	NA NA	NA NA	NA NA	III III	NA NA	NA NA
1	Commercial	Prototype	Poor	Low	Max	Poor	II	D	32
2				Low	Max	Good		D	31
3				Low	Min	Poor		D	30
4				Low	Min	Good		D	29
5				High	Max	Poor		C	24
6				High	Max	Good		C	23
7				High	Min	Poor		C	22
8				High	Min	Good		C	21
9			Good	Low	Max	Poor		B	16
10				Low	Max	Good		B	15
11				Low	Min	Poor		B	14
12				Low	Min	Good		B	13
13				High	Max	Poor		A	8
14				High	Max	Good		A	7
15				High	Min	Poor		A	6
16				High	Min	Good		A	5
17		Operational	Poor	Low	Max	Poor	I	D	28
18				Low	Max	Good		D	27
19				Low	Min	Poor		D	26
20				Low	Min	Good		D	25
21				High	Max	Poor		C	20
22				High	Max	Good		C	19
23				High	Min	Poor		C	18
24				High	Min	Good		C	17
25			Good	Low	Max	Poor		B	12
26				Low	Max	Good		B	11
27				Low	Min	Poor		B	10
28				Low	Min	Good		B	9
29				High	Max	Poor		A	4
30				High	Max	Good		A	3
31				High	Min	Poor		A	2
32				High	Min	Good		A	1

The final factor in selecting advanced tools is the priority rating. This number is found in the last column in Table 3. After completing the Trade-off Criteria Decision Tree Form, the tracking number located on the bottom of the form is used as the initial entry to the Advanced Tool Assessment Form. The entry position in the first column is then tracked horizontally across Table 3 until a Priority number is reached in the last column. The priority number assigned to a tool represents a quantitative distinction among the tools in the data base. This number reflects the priority which should be given to the selection of a tool, when tools of a similar type and class have been identified.

2.5.3 RESULTS

The results of the trade-off process can be found in Appendix B. Presented, in the table, from left to right, is the tool's record number, which corresponds to the record number used to access the tool in the data base. The name of the tool is presented next, followed by information used to classify the tool (i.e., MAP Phase, HFE Activity Area, Tool Type, Tool Class), and the priority assigned to the tool. Tools designated with a 0 are either Proprietary or Conceptual, and were therefore excluded from the assessment process. The last column presents the overall cost assessment of the tool, which is taken from Appendix C. Given similar capabilities, and for tools of the same Type and Class, consideration should be given to the tool with the highest priority classification (lowest number) and the lowest cost. It should be emphasized that the tools priority ranking is based on an ordinal scale of measurement, and should therefore only be used as a general guide when selecting tools.

Appendix C presents the cost criteria which were used as the basis in determining the overall affordability of a tool. A tools overall cost, presented as Low, Moderate, or High, represents an integration of four different cost considerations. The first, Acquisition Cost, refers to the sum of money required to procure a tool. An attempt was made to provide information on the absolute cost of a tool, when this information was available. In most cases, it was not. The development of many of the tools in the database was funded by government agencies. Since these tools fall within the public domain, they normally can be released free of charge (except for the cost to reproduce them), to Federal, state and local government agencies. These tools received a score of "None" under the category Acquisition Cost. Tools costing less than or equal to $1,000 were scored "Moderate" on the acquisition cost category, while tools costing in excess of $1,000 were labeled "High" acquisition cost.

The next category, Setup Cost, refers to the amount of front-end work required on the part of the user before a tool can be implemented effectively. Such costs were designated "Low," "Moderate," and "High," and were determined subjectively through both verbal and narrative descriptions of the tool, and by conferral among the reports authors.

The third category, Training Cost, was included to differentiate tools by the amount of time

required for a user to become proficient in their use. A "Low" training rating was assigned to any tool that could be mastered in one day. A tool requiring up to three days for a novice user to learn received a rating of "Moderate." Tools requiring more than three days to learn were rated "High."

The final category was Resource Costs or costs associated with the computer system for which the tool was designed. Tools were rated "High" in resource costs if a mainframe computer was required to run them. A tool was rated "Low" if it could run on a microcomputer.

Overall cost ratings were obtained by averaging the ratings over the individual cost categories. The Overall Cost rating could be "Low," "Medium," or "High" based on an equal weighting of the four categories.

Regarding recommendations for specific tools, operational tools with good adaptability and demonstrated utility which fall toward the low to moderate end of the cost spectrum are recommended for procurement by the Army. Such tools are all Category I, Level A tools, with priority ratings between 1 and 4. A total of 12 tools exhibit the above characteristics, and are identified below:

- SIMWAM
- HF-ROBOTEX
- GRASP
- ZITA
- MicroSAINT
- CAR
- DART
- WOSTAS
- WORG
- GEOMOD
- CADAM/ADAM & EVE
- CAPRA

While the above twelve technologies do not represent an inclusive set of advanced tools which can be applied to all problems encountered within the field of human factors engineering, they do represent the best Types of tools within their respective tool Classes. Although the recommendations are based on a thorough review of the literature and on conversations with tool developers and people experienced in applying the tools, the authors did not have the opportunity to test the tools reported herein individually.

Potential tool users should also bear in mind that recommendations for the above tools are only as good as the task the human factors specialist is faced with. Therefore, given mission objectives, the specialist should select the tool(s) which best satisfy the requirements of the task objectives. To facilitate the selection of the ideal advanced tool, a human factors engineering advanced tools database has been created. This database offers unlimited query capabilities to allow the human factors specialist to custom tailor a search to meet the specific objectives of the task. The generic search features built into the database, including the Custom Search Menus and Quick Query feature, are fully described in the database User's Guide presented in Appendix D.

3.0 RECOMMENDATIONS

The specific tools already in existence which should be procured are heavily dependent upon the functions the tools are to perform. Assuming, of course, that the functional requirements have been met, those advanced tools which possess the capabilities of satisfying task objectives, and which rated favorably in the trade-off process, are those recommended for procurement and use.

The results of this study indicate that advanced tools running on a microcomputer for use within military R&D and T&E programs would be a welcome addition to the Army's standard tool set. When looking at the frequency of citations for a particular type of advanced tool, the data clearly indicate that automated task analysis programs, human factors data base compendiums, workload prediction tools, and expert systems were all in the forerunning. In selecting among the general types of tools requested for future development, the specific tool which should be developed during the Phase II effort should be one which best supports the objectives of the Phase I task as delineated in the RFP and corresponding technical proposal.

The research conducted during the course of this contract was intended to support the initiatives of the Army's MANPRINT program. As part of another MANPRINT study conducted by Carlow Associates and FMC within the FMC IR&D program, a subtask was undertaken to identify the tools involved for each of the MANPRINT domains. The results yielded the identification of over 100 models, methods and data bases used in support of the MANPRINT process, spanning the domains of HFE, MP&T, HHA, and SS. The Phase I scope for the present study was limited to those advanced tools presently used by the human factors community; data bases, along with manual techniques and methods, were not of primary concern and, therefore, were not subjected to the rigorous classification and categorization scheme developed to screen existing advanced tools.

A recommendation for future work would be to combine the results of the present study with the results of the previous MANPRINT study, and use this aggregate as a springboard into the development of a standard front-end analysis (FEA) process based on existing and proposed human factors engineering technology. The technology to be surveyed should incorporate the advanced tools identified during this Phase I SBIR with the traditional manual techniques, procedures, models and data bases surveyed during the IR&D program, to study the MANPRINT process as applied to Army systems. The resulting product would be documentation of the role HFE technology plays during FEA in major weapon system acquisitions. Corollary products might include the development of software technologies identified as necessary for facilitating the front end analysis process, and possibly even a knowledge oriented data base or expert system which could be used for selecting the HFE technologies available during the FEA preceding the acquisition of major systems. Such an approach would satisfy both the letter and intent of the

Phase I scope by providing a tool or tools which compliment the objectives of the MANPRINT program, while simultaneously ensuring that the resulting product is one which is desired by the human factors practitioners within the military sector.

In responding the the question regarding the advanced tools preferred for adaptation to a desk top computer, the microcomputer of choice for future software adaptation or development was the Apple Macintosh. This response is not surprising in that over a decade of human factors research went into the development of the interface for this particular machine (over 30 work years if one considers the Xerox 8010 Star Information System as the father of the Macintosh). The research on cognitive modeling conducted during the R&D phases associated with these two machines resulted in the birth of the desktop metaphor and the introduction of direct manipulation languages. In developing the interface for these machines, the user's conceptual model was developed before the software was written. The interface was designed before the functionality of the system was fully decided, even before the computer hardware was built (Smith et al., 1982). The positive response to the Macintosh is due largely to this interface which supports both rapid skill acquisition and retention over time. For these reasons, any software planed for future development on a microcomputer by the Army should be configured with a Macintosh in mind.

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DISTRIBUTION LIST

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APPENDIX A

ADVANCED HUMAN FACTORS ENGINEERING TOOLS DATA BASE

TOOL NAME: CRAFT (Computerized Relative Allocation of Facilities) Aviation Related? yes Record # 1

DESCRIPTION

A computer program for identifying optimum control and display layouts on a panel based on movement requirements, frequency of control and display use, control and display distance, initial panel layout, frequency of use for each control and display, eye and head motion rate data, eye and hand workload data.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• source panel layout • movement requirements • frequency of control and display use • eye and hand motion rate data • eye and hand workload data	• layout changes • cost factors (trade-offs) • figure of merit • panel layout minimizing visual and motor transitions • total time cost layout	• IBM 370

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** design

ROLE
- control and display panel layouts

TYPE CAD

CLASS
- panel design

STATUS operational

COST Moderate

ADVANTAGES

- computes cost factors that can be used to determine minimum cost of subpanels

DISADVANTAGES

- does not make functional or sequential evaluations
- panel configurations are determined principally from eye travel transition distances

SOURCE

Naval Oceans Systems Command (NOSC)
San Diego, CA 92152

REFERENCES

Baker, et. al., 1979

COMMENTS

TOOL NAME: WOLAP (Workspace Optimization and Layout Planning) **Aviation Related?** yes **Record # 2**

DESCRIPTION

A computerized program for identifying optimum control and display layouts on a panel-similar to CRAFT. Method of operation: an initial panel layout is evaluated by the program and a cost figure computed, then the panel components are randomly rearranged and cost is computed for this arrangement. The user determines the number of times he wants the layout rearranged and the cost computed. When all the desired layouts have been analyzed, the computer selects the three with the lowest cost. These three and the initial layout are then printed, along with the cost calculations for each. Considerations in figuring the cost function of WOLAP are transition distances (visual, manual), weighting of components that are accessed, and the probability of transitions. WOLAP can be implemented at the component, subpanel, or panel level.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• relative inputs of all panel components in an X-Y plane • frequency array data table • visual null • manual null • total number of instrument components • number of iterations required • relative weighting of controls	• a specified number of layouts and costs are worked up • the 3 layouts with the lowest cost and the initial layout are printed for comparison	• IBM 370

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** design

ROLE
- control and display layouts

TYPE CAD

CLASS
- panel design

STATUS operational

COST High

ADVANTAGES

- advantages over CRAFT: produces many quantitatively optimized solutions; functional and sequential links are evaluated

DISADVANTAGES

- panel configurations are determined principally from eye travel transition distances

SOURCE

University of Waterloo
Ontario, Canada

REFERENCES

Baker, et. al., 1979

COMMENTS

TOOL NAME: HECAD (Human Engineering Computer-Aided Design) — Aviation Related? yes — Record # 3

DESCRIPTION

HECAD eliminates the stage of building workstation mockups in evaluating complex design concepts. The program involves the use of two subprograms: INDICODE and DEWO. INDICODE is run first, then DEWO uses its results. Workstation operability is determined by estimating activation times and reliabilities of panel components (toggles, pushbuttons, etc.) in INDICODE. The designer specifies the components of a panel via a lightpen or CRT. INDICODE computes and prints the estimated time and reliability of each component of the panel for the user. The punched cards are used as input for the second program, DEWO. The next step is for the designer to arrange the individual components (50 maximum) within the workspace confined to less than 11 panels. Task sequences are then entered. Tasks are the sequence of control display use and are for the sole purpose of determining the visual or motor transition times (reaching, turning, and eye travel). Times are computed from Methods-Time-Measurement (MTM) formulas. The end point for one task equals the beginning point for the next. A simulation is performed where the tasks are executed, interacting with the components. DEWO extracts the execution time for each task and performance reliability, and the number of times each component is used during a task sequence. This sequence can be reiterated until a successful arrangement of components has been found.

REQUIREMENTS

INPUT REQUIREMENTS

INDICODE input:
- the components of a panel

DEWO input:
- a definition of a single (3-D) workspace to be evaluated
- the results of INDICODE: each component of the workspace is identified by the component number, activation time, component dimensions, and for rotating controls, the angular setting
- task sequences

OUTPUTS

INDICODE output:
- the estimated time and reliability of each component of the panel

DEWO output:
- listing of panel equations
- task sequence
- ID number, current location, number of times the component is used for each task sequence, activation time, and performance reliability for each component
- summary table identifying all actions associated with task
- task sequence results: number of actions/sequence, time that hands or eyes are active, communicaton times, total task times, task reliability
- the thirty longest transfer times (displayed in order)

RESOURCE REQUIREMENTS

- IBM 370/165

CLASSIFICATION

PHASE: FSD

APPLICATION: advanced

ACTIVITY: design

ROLE:
- evaluates panel layouts as a function of motor/visual transfer

TYPE: CAD

CLASS:
- panel design

STATUS: operational

COST: Moderate

ADVANTAGES

- obviates the necessity for building workspace mockups
- determines 3 different types of transition times; reading movements, turning movements, and eye travel
- provides an indication of system operational effectiveness in terms of human reliability

DISADVANTAGES

- runs in batch processing mode; requires punched cards

SOURCE

US Air Force Aerospace Research Lab
Aerospace Medical Division
Air Force Systems Command
Wright-Patterson AFB, OH 45433

REFERENCES

Baker, et. al., 1979
Aume, & Topmiller, 1972

COMMENTS

TOOL NAME: TEPPS (Technique for Establishing Personnel Performance Standards) **Aviation Related?** yes **Record #** 4

DESCRIPTION

Computerized technique for estimating the probability of task completion and task performance time. TEPPS is a technique for determining the effects of operator error. TEPPS is designed to "derive specific personnel performance standards with definite relations to system effectiveness requirements." TEPPS allows the human factors engineer to develop personnel performance standards that can serve as yard sticks for comparison with operational performance requirements. Applied in 5 steps using 2 models: Graphic State Sequence Model (GSSM) - essentially a flow block diagram, and Mathematical State Sequence Model (MSSM) - essentially a reliability block diagram. MSSM consists of the dependency and redundancy relationships among task pathways in the GSSM. Computation of the MSSM is done by a computer program in the TEPPS package.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• system description • task data • task times • task reliabilities • establish personal-equipment functional (PEF) probabilities • determine predictive data for GSSM units • GSSM data and predictive data for MSSM	• analyzed and derived system reliability • probability of successful task accomplishment • task execution time estimates	• mainframe (unknown)

CLASSIFICATION

PHASE CE, D&V

APPLICATION advanced **ACTIVITY** analysis

ROLE • determination of the effect of design alternatives • determination of design components most likely to cause errors

TYPE functional model

CLASS
- FEA
- performance analysis
- task modeling

STATUS operational

COST High

ADVANTAGES

- explicit procedure for deriving data requiring subjective estimates
- can be used as both an evaluation and a design tool

DISADVANTAGES

- limited in its inability to handle both continuous and decision making tasks

SOURCE

Navy Personnel Research and Development Center
San Diego, CA 93102

REFERENCES

Baker, et. al., 1979

COMMENTS

TOOL NAME: SAINT (Systems Analysis of Integrated Networks of Tasks) I&II — Aviation Related? yes — Record # 5

DESCRIPTION

SAINT is a network modeling and simulation technique developed to assist the system designer and human engineer in design and analysis of complex man-machine systems. It relies on a task network exercised as a series of prescribed relationships. Each task is described with respect to resources, information attributes, task statistics, priorities, and "state" variables. SAINT provides a graphical symbol set for diagramming event sequences. It aids engineers in applying network theory and simulation to operations and systems analysis problems. SAINT also allows a description of human activities in terms of a set of tasks performed by a crew or set of operators. SAINT is useful for crew sizes of up to eleven. The impact of nuclear weapons on human performance has been worked into the system.

REQUIREMENTS

INPUT REQUIREMENTS

- detailed definition of task networks
- resources
- task data
- task priorities
- system status variables

OUTPUTS

- mission success data
- task time data
- mission times
- various outputs of the simulation, histograms, plots, summary statistics

RESOURCE REQUIREMENTS

- uses FORTRAN on a mainframe
- UNIX
- IBM
- CDC 6600

CLASSIFICATION

PHASE CE, D&V, FSD

APPLICATION advanced **ACTIVITY** analysis, T&E

ROLE • determining survivability of manned systems • mission effectiveness criteria • detailed design req. • operational procedures div. • training sys. div. • maintenance sys. div.

TYPE task model

CLASS
- FEA
- workload analysis
- task modeling

STATUS operational

COST High

ADVANTAGES

- SAINT II: includes techniques for enabling the user to model continuously changing variables such as aircraft position in space, engine temperature, fuel consumption. This enables the HFE analyst to specify how the discrete control tasks in the network influence these system state variables.
- SAINT III: (prototype) ability to describe and assign individual characteristics to each of the crew members being simulated
- SAINT III: (prototype) HE included through means of task parameter specifications, task sequencing relationships and psycho-social and environmental factors effecting operator performance

DISADVANTAGES

- limitation of SAINT I: does not provide for representation of the dynamic nature of systems
- requires considerable knowledge of the operating system and programming language
- no help function

SOURCE

US Air Force Aerospace Medical Research Laboratory
Aerospace Medical Division, AFSC
Wright-Patterson AFB, OH 45433

REFERENCES

Baker, et. al.., 1979
Geer, 1976
DOD-HDBK-XXX, 1986

COMMENTS

TOOL NAME: COMBIMAN (Computerized Biomechanical Man-Model) Aviation Related? yes Record # 6

DESCRIPTION

A design aid to anthropometrically fit operators to workspaces. Two submodels: man model, and workspace design model. Permits the development of a three dimensional workspace. COMBIMAN is a CRT graphic display man-model system used primarily in the design of crewstations and workplaces. It is comprised of a system of programs developed to assist in the design process. It is an interactive, computer graphics, assisted engineering tool. It produces a three dimensional man-model that can be viewed from any plane or angle. The man-model is based on a 35 link-skeletal system. COMBIMAN is a 3-D model that may be moved about and viewed from any angle. The entire anthropometric range of a given user population may be quickly defined in a series of man-models. The man-model is constructed in three stages. First, the 35-segment link system is generated. Second, the enfleshment ellipsoids about the link system joints are defined. And third, the ellipsoid silhouettes are connected by tangent lines. COMBIMAN can be used to evaluate existing workspaces, conceptual workspaces (exist as engineering drawings), and workspaces generated with the lightpen in on-line design operations. COMBIMAN includes visibility plots that are easily acquired through the accurate difinition of a complex range of head and eye positions.

REQUIREMENTS

INPUT REQUIREMENTS

- direct anthropometric measures of subjects
- database percentages
- combinations of measures and data base measures
- required population dimensions (to fit a workspace)
- required or established maximum rational angles
- bodily restrictions such as clothing

OUTPUTS

- a 3-D man-model that can be viewed from any plane or angle (the man-model is based on a 35 link-skeletal system)
- an indication of successful or unsuccessful reaches given a specific workstation envelope and anthropometric data of an operator

RESOURCE REQUIREMENTS

- COMBIMAN is run on an IBM 360/370 computer in FORTRAN.

CLASSIFICATION

PHASE: FSD

APPLICATION: advanced

ACTIVITY: design

ROLE: • design and evaluation of new workspaces • personnel selection criteria for workspaces • mapping of external visability plots • evaluation of specific workspaces

TYPE: graphic man-model

CLASS: • workstation design

STATUS: operational

COST: High

ADVANTAGES

- the user can temporarily remove certain characteristics from the display without eliminating them from storage to unclutter the screen
- any workplace constraints that govern the design process may be entered directly and stored in the database
- determines minimal and maximal reach distances
- represents humans and the workspace in 3-D
- interactive color graphics
- addresses single and multiple reaches
- allows visual determination of body clearance problems

DISADVANTAGES

- runs in a batch processing mode
- regression equation inappropriate for modeling females
- does not consider the effects of clothing on body position and joint limitations of motion
- can only be used with single seated operator workplaces

SOURCE

AF Aerospace Medical Research Lab
HE Division
Workload and Ergonomics Branch
WPAFB, OH 45433

REFERENCES

Baker, et. al. (1979)
DOD-HDBK-XXX, 1986

COMMENTS

TOOL NAME: SIMWAM (Simulation for Workload Assessment and Modeling) **Aviation Related?** yes **Record # 7**

DESCRIPTION

SIMWAM is a microcomputer-based task network modeling technique for assessment of operator workloads and performance effectiveness in man-machine systems. It consists of a set of related interactive programs which allow the analyst to create a database of task requirements, execute the task network, obtain performance data and modify the network or tasks to evaluate alternate concepts for manning, allocation of tasks to operators or interface design. Task definitions, flow relationships, and task parameters are based on system documentation, information from subject-matter experts or other appropriate sources.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• a task network model of the system to be analyzed • predecessor/successor relationships between tasks • task call structure following task completion • list of operators qualified to perform each task • task duration time parameters (minimum, mode, and maximum) • dependence of task duration on process variables (if applicable) • task priorities • task interruption parameters • user-written subroutines (if applicable)	• task summary with task number, start time, end time, duration, completion number, operators assigned, task interruptions and terminations • task status with completions, operator time expended and call status for each task • operator workload showing busy/idle times • time matrix showing time expended on each task by each operator	• TRS 80-Model IV 128K dual disk drives In the process of being adapted to Apple Computer's MacIntosh.

CLASSIFICATION

PHASE: D&V, FSD, PI, CE, Pre-Con, P&D

APPLICATION: advanced

ACTIVITY: analysis, T&E

ROLE:
- applied to Aircraft Carrier Air Operations, Surface Ship Air Detection and Tracking Area and Surface/Subsurface Area

TYPE: task model

CLASS:
- workload analysis
- T&E
- FEA

STATUS: Operational

COST: Low

ADVANTAGES

- SIMWAM can be run on a microcomputer
- SIMWAM programs are menu-driven and prompt the analyst for all necessary inputs
- the interactive nature of the program allows models to be rapidly debugged or modified
- large networks can be run on a microcomputer. A network involving 550 tasks and 34 operators has been run on the 64 K version.
- task calls can be probabilistic or conditional on logic applied to system process variables. This allows flexibility in developing task call logic which corresponds to that of the system being modeled.
- SIMWAM handles multi-operator workspace situations in which operators may swap duties, depending on conditions, and may defer completion of lower priority tasks if performance is required on higher priority tasks

DISADVANTAGES

- SIMWAM is excruciatingly slow in executing large models. Conversion to a faster micro may help but it will never be any SAINT as far as run time is concerned
- SIMWAM provides only the triangular distribution for monte carlo determination of task duration samples
- taking advantage of SIMWAM capabilities which involve dependence of task duration and task call logic on process variables requires that the user write subroutines in BASIC and merge them into the main program

SOURCE

Dr. Mark Kirkpatrick
Carlow Associates Incorporated
8315 Lee Highway, Suite 410
Fairfax, VA 22031

REFERENCES

DOD-HDBK-XXX, 1986
Kirkpatrick, 1986

COMMENTS

TOOL NAME: ORACLE (Operators Research and Critical Link Evaluation) | Aviation Related? yes | Record # 8

DESCRIPTION

A diagnostic and workload evaluation tool that simulates the input and processing rates of information nodes and links in an information flow system. For man-machine systems application, the assumption has to be made that nodes may be modeled to represent human operations. ORACLE is used to determine the number and types of personnel required for a task mixture (man-machine allocations) and system configuration, the determination of design change effects on system effectiveness, the identification of critical elements (paths) in an operational sequence, and measurement of the effectiveness of degradation of individual system functions.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• input rates for information units (messages/unit time) • message initiation times • message response times • message priorities, probabilities of events occurrence based on equipment availability and reliability criteria	• prediction of total processing time required for a given series of events (tasks) • the identification of queues of information representing node overloads	• mainframe (unknown)

CLASSIFICATION

PHASE D&V, FSD

APPLICATION advanced **ACTIVITY** analysis

ROLE
- determination of design change effects on system effectiveness

TYPE info flow model

CLASS
- workload analysis
- task analysis

STATUS operational

COST High

ADVANTAGES

- provides a timeline history of system's operations

DISADVANTAGES

- not developed from a behavioral perspective

SOURCE

Westinghouse R & D Center
1310 Beulah Rd.
Pittsburg, PA 15235

REFERENCES

Baker, et. al. (1979)

COMMENTS

TOOL NAME: TREES (Tree Structured Data) Aviation Related? yes Record # 9

DESCRIPTION

A computerized method designed to provide maintenance technicians with technical data. It provides for modifications to maintenance data and tally proceduralized guidance through system checkout and repair activities.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• through a query subroutine, TREES gains information on the system failure and eventually isolates the problem • tree structured maintenance data	• as the problem is being zeroed in on, TREES gives the technician data and instructions. When he completes each set of instructions, the technician answers the next phase of questions. This helps TREES to move down the branches of the system and isolate the problem and provide the solution.	• 5 subprograms: Build, Loads, Edit, Bump, Query • mainframe (unknown)

CLASSIFICATION

PHASE	FSD	CLASS	• procedures • maintenance
APPLICATION	advanced	ACTIVITY	design
ROLE	• step-through maintenance routines	STATUS	operational
TYPE	data access	COST	Moderate

ADVANTAGES

- can be adapted to any type of maintenance activity or any system

DISADVANTAGES

- is not an expert system, and therefore contains no explanation facility to assist technicians

SOURCE

Systems Development Corporation
1755 Old Meadow Rd.
McLean, VA 22102

REFERENCES

Baker, et. al., 1979
Heasly, 1986

COMMENTS

TOOL NAME: TX-105 (Operator/Crew Workload Assessment Technique TX-105) **Aviation Related?** yes **Record #** 10

DESCRIPTION

TX-105 is a computerized tool which helps evaluate the workload of aircraft crews and cockpit size. TX-105 employs three subroutines. The first two calculate angles between the eye and points within a cockpit, and the third computes linear and angular distances of eye and hand movements during task performance. Link 1 assumes the eyes are one point; Link 2 assumes a binocular camera viewpoint; and Link 3 calculates the angular and linear distance changes for the eyes and hands as they move to perform flight procedural tasks. The configuration with the shortest linear distances and the smallest angular eye movement is the most efficient.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
General input: • cockpit geometry information -control locations -display locations -control and display labels -eye and shoulder reference points • task data -name -sequence of tasks -point to point sequence of tasks within the workspace Link 3 inputs: • control and display nomenclature and location • crewmember eye and shoulder reference points • task ·ne • seq .nce of points for each task • sequence of tasks for each mission segment	Link 3 outputs: • implications to workload as measured by the angular changes and changes in linear distance for both operator eyes and hands • the sums of these angles and distances for each mission segment	• mainframe (unknown)

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** analysis

ROLE
- may be used as a design tool
- assisting in selecting a design concept which minimizes time and motion requirements of operation.

TYPE workspace model

CLASS
- workload analysis

STATUS operational

COST Moderate

ADVANTAGES

- obviates the necessity for building complex system workspace mockups
- determines 3 different types of transition times; reaching movements, turning movements, and eye travel

DISADVANTAGES

- does not provide an indication of system operational effectiveness in terms of human reliability

SOURCE

Boeing Aerospace Co.
1399 Bay Area Blvd
Houston, TX 77058

REFERENCES

Baker, et. al., 1979
Geer, 1976

COMMENTS

TOOL NAME: TLA-1 (TimeLine Analysis Program-Model 1) Aviation Related? yes Record # 11

DESCRIPTION

This computerized tool estimates operator workload for task sequences within given flight scenarios.
The TLA-1 program is implemented in four successive steps:

1. scenario development-identify mission milestones, estimate event times from mission flight plans, operations, manuals
2. derive task data for each task, estimate task duration time, and identify channel activity (left foot operated, right foot, hands, external visual, internal visual, cognition, auditory or verbal)
3. develop task timeline-code on a worksheet task name, identification number, start time, and duration time for each task
4. codify the data for keypunching

A wide variety of workload analysis data formats are available. Up to six digital reports and four data plots may be requested. Standard sets of reports and plots have been defined that may be specified by number. Workload problems may be exposed in greater detail by selecting different output types and placing tighter control over the variables.

REQUIREMENTS

INPUT REQUIREMENTS

- data for step 1 comes from flight plans, aircraft performance data, and aircraft operations manuals
- data for step 2 comes from operator's manuals, human performance databases (reach times, eye fixation/rotation times), task analysis, and task simulation

General input:

- mission requirements
- system requirements
- system design concepts
- system operational concepts
- military specifications and standards
- human performance data
- equipment characteristics and performance data
- advanced technology forecasts
- previous system experience
- assumptions (as required, i.e. in a new system)

OUTPUTS

General output:

- task time intervals
- channel group workload
- weighted average channel workload (average channel workload)
- mean variance
- workload variance
- workload standard deviaton

Printer output:

- mission scenario report
- crewman workload profile report
- crewman workload summary status report
- task channel activity report
- subsystem activity report
- subsystem activity summary report
- task list report

Graphical plotter output:

- channel activity summary plot
- workload histogram report
- workload summary plot
- mission timeline plot

RESOURCE REQUIREMENTS

- mainframe (unknown)

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** analysis

ROLE • mission effectiveness criteria • detailed design reqs • concept formulation ideas • personnel reqs info • sys-ops evaluation • additional HF analysis • HFE data store info

TYPE task model

CLASS
- workload analysis
- FEA
- task modeling

STATUS operational

COST High

ADVANTAGES

- provides integrated graphic workload assessments
- adaptable to any crew station
- provides wide variety of workload analysis data formats

DISADVANTAGES

- if used for absolute evaluations, scenario data must come from existing similar aircraft
- operates in batch processing mode

SOURCE

NASA Langley Research Center
Hampton, VA 23665

REFERENCES

Baker, et. al., 1979
Geer, 1976

COMMENTS

TOOL NAME: SAMMIE (System for Aiding Man-Machine Interaction Evaluation) Aviation Related? yes Record # 12

DESCRIPTION

SAMMIE is an interactive CAD human factors evaluation system. SAMMIE consists of three main groups of independent modules. The first is the 3-D Assembler Modeler. With this module, a designer can simulate equipment for testing in 3-D by arranging geometrical shapes. The second module, the Man-Module, enables the designer to construct an anthropometric 3-D bio-mechanical man-model to represent any size or shape person. Population percentiles and combinations of percentiles can be represented in SAMMIE. The man-model is complete with 19 connected links and joints that can be used for manipulating him into various positions for assessing reach, vision, and fit. The final module is the Analysis Facility. This permits SAMMIE to provide interactive testing by allowing the designer to "assume the user's position" and see what his model sees; even concave, convex or plane mirrored images (i.e. in a car rearview mirror) can be projected. The designer can enter and walk around in his model to inspect every aspect of it. There is also a zoom capability for close scrutiny of any portion of the layout. One of the most useful analysis facilities of the program is the automatic generation of "Aitoff" projections used for analyzing airplane cockpits. In about 3 minutes, SAMMIE can produce a chart that encompasses 360 degrees of view in the horizontal plane and 180 degrees of view in the vertical plane.

The language used to operate SAMMIE is pseudo-natural in that everyday English words (move-shift, rotate) are used to manipulate the modules. These commands can either be keyed in or selected from a tablet.

REQUIREMENTS

INPUT REQUIREMENTS

Man-model inputs:
- the specific characteristics of individual people
- the anthropometric category in which the man -model will fit

3-D equipment model inputs:
- the geometrical information defining the solid object (workstation)
- the location and orientation of the object relative to the group in which it belongs
- the logical relationships between the objects and their owner
- modifications (pre-specified movements)
- sequences (pre-specified sequences of movements)

OUTPUTS

- fit assessment
- reach assessment
- visibility assessment
- the exact state of the model at that moment; the model can be interactively modified as required
- aitoff projections

RESOURCE REQUIREMENTS

- any Prime 50 Series 32-bit computer with the PRIMOS operating system

CLASSIFICATION

PHASE D&V, FSD

APPLICATION advanced, mini **ACTIVITY** design, evaluation

ROLE plane cockpits, body dynamics, articulated hand, safety factors, field of view and "blind spots"

TYPE workspace model

CLASS
- workspace design
- workplace design
- reach
- vision

STATUS operational

COST High

ADVANTAGES

- field of view from design eye perspective
- built-in help and tutor facilities
- constantly updated
- anthropometric data reflecting either MIL-STD-1472C or Dreyfuss dimensions
- represents humans and workspace in 3-D
- interactive color graphics
- addresses single and multiple reaches
- allows visual determination of body clearance problems
- includes comfort joint limits
- includes somatotype representation
- includes multiple default postures
- includes simulataneous views
- includes mirror reflections
- includes visibility diagrams
- includes default views of display
- includes definition of acceptance angle to simulate visual field
- workspace objects are modeled internally

DISADVANTAGES

- system specific - runs only on PRIME computers
- does not provide reach assessment capability, only arm length
- cannot enter anthropometric measures-user must compute link dimensions and enter them himself
- regression equation inappropriate for modeling females
- does not consider the effects of clothing on position and joint limits of motion
- stick-figure, poluhedral and shaded representation of man not modeled
- does not light sources and shadows
- does not contain a plane clipping feature (cut-away views)
- no real-time graphical display
- offers only two hand reach types as opposed to three

SOURCE

PRIME Computer, Inc.
1375 Piccard Drive
Rockville, MD 20850
(301) 948-7010

REFERENCES

Hickey, et.al., 1985
Prime Computer, 1985
Rose, 1986

COMMENTS

TOOL NAME: CAPABLE (Controls And Panel Arrangement By Logical Evaluation) Aviation Related? yes Record # 13

DESCRIPTION

CAPABLE is a program which produces arrangements of controls and panels by logical evaluation. The procedure for operation of the algorithm governing CAPABLE is as follows: run the preliminary analysis, determine the workspace geometry, run limb assignment routines, figure the component layout, and finally take performance measurements. Eventually CAPABLE will be able to predict the likelihood of accidental operation. As conflicts with the conditions specified by the user in the initial layout occur, the routine decides to what degree prominences should be relaxed and where trade-offs should occur.

REQUIREMENTS

INPUT REQUIREMENTS

- number and relative location of panels
- the operator's location and orientation with respect to the panels
- the controls and *whether specific ones must* be on specific panels
- preassigned groups of controls
- work tasks to be performed on the control layout
- meta-tasks: groups of work tasks
- the prominence of each rating of the measures below

Measures used:

- separation of the controls on each panel
- the extent to which the work load should be equally distributed among the limbs
- the degree to which pregrouping of controls must be maintained
- the extent to which the program should conform to the range of percentiles that the projected users fall into
- the level of comfort required for the operation of the controls
- accidental operation

OUTPUTS

- base time for each sequence
- base distance for each sequence

RESOURCE REQUIREMENTS

- program was written in ALGOL 60 for ICL 1906A or ICL 4130 computers

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** design

ROLE
- design of control panels for aircraft cockpits
- design of control panels for steel mill pulpits

TYPE graphic

CLASS
- panel design

STATUS operational

COST High

ADVANTAGES

- eliminates complex and time consuming steps in designing control layouts and panels
- allows process control decisions to be based on valid ergonomic principles

DISADVANTAGES

- difficult to assess the quality of the results
- difficult to assess the economic validity of such a system
- procedure for modeling accidental operation has not been completed

SOURCE

University of Nottingham
Nottingham, England

REFERENCES

Bonney, & Williams, 1977

COMMENTS

TOOL NAME: Micro SAINT (Micro-Systems Analysis of Integrated Networks of Tasks) **Aviation Related?** yes **Record #** 14

DESCRIPTION

Micro SAINT is a microcomputer version of the simulation SAINT (Systems Analysis of Integrated Networks of Tasks). Micro SAINT simulates the activities of human operators within complex systems. It was designed to facilitate use by a nonsimulation expert. Micro SAINT simulates system and operator performance by first initiating a task; second, examining factors effecting task completion time; third, by modifying task completion time factors; fourth, selecting subsequent tasks to be executed; and finally, surveying factors effecting task release. This sequence continues until the scenario is completed. Scenarios may be linked together to form a mission. In designing Micro SAINT, the designers targeted the system for use by human factors specialists. The interface for Micro SAINT is menu driven because of the ease with which an inexperienced user may begin to work with the system.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• identify sequence of tasks and task characteristics • identify resources • identify information attributes • specify task statistics • specify task priority • identify resource attributes • specify moderator functions • identify system attributes • specify state variables (e.g. fuel supply status over time)	• mission success data • task completion time data • histograms • plots • summary statistics	• IBM PC compatibility • MS-DOS or PC-DOS version 2.1 or later • 512K bytes RAM • Two floppy disks or one floppy and a hard disk

CLASSIFICATION

PHASE Pre-con, CE, D&V, FSD, P&D, PI

APPLICATION advanced **ACTIVITY** analysis

ROLE
- building and executing task network models, specifically models of human operators

TYPE task model

CLASS
- workload analysis
- FEA
- task modeling

STATUS operational

COST Moderate

ADVANTAGES

User-interface advantages:
- no coding-neither user code nor recompilation is required
- no manuals-HELP function has over 50 help screens
- user-friendly language-menu oriented; consistent commands
- more available software-written in "C"; runs on an IBM PC or compatible with 256K of memory
- integration with other applications-Lotus 1,2,3, Symphony, etc.
- a conceptual framework for expressing problems-models are constructed as task networks
- debug execution mode
- "snapshot"-allows user to customize data collection process
- output data can be analyzed within the program
- data files can be read by Lotus 123 for plotting

DISADVANTAGES

- Micro Saint users cite the lack of windows as the programs biggest disadvantage

SOURCE

SAINT-US Air Force
Micro SAINT-Micro Analysis and Design
9132 Thunderhead Drive
Boulder, CO 80302

REFERENCES

Laughery, 1984

COMMENTS

TOOL NAME: FLAIR (Functional Language Articulated Interactive Resource) Aviation Related? yes Record # 15

DESCRIPTION

FLAIR allows a designer to rapidly prototype a system's man-machine interface. It is a color graphics based computer graphics tool that is capable of prototype generation and interpretative or compiled execution of the developed prototype. FLAIR contains both an interactive Dialog Design Language, and a User Interface Management System. Interactive dialogs can be generated for both single or multiscreen graphics systems. The show-by-menu system facilitates teaching on the VAX, and there is an ever-present help menu available to users. FLAIR can support static frames, scenario dialog, and dynamic system scenario. The 4 primary tools of FLAIR are: the FLAIR generation execution system, the compilers, the kernal FLAIR, and the environmental generators. The Kernal executes a compiled version of the prototype instructions. The Kernal can be connected to the Environmental Generator Executive (EGE). This EGE can control user written data to simulate the environment for the system being designed. The EGE is the central link for the Kernal FLAIR (KFLAIR). A KFLAIR looks like just another EG Unit.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• the hypothetical system's objectives • requirements analysis • function analysis • task analysis	• a prototype of a man-machine interface	• VAX • a graphics terminal • VT-100 or compatible terminal

CLASSIFICATION

PHASE: FSD

CLASS: UCI Design

APPLICATION: advanced

ACTIVITY: design

ROLE: • CAI systems • C3I systems • CAE systems • Cartographic systems • front-end driver for decision support for various prototype systems

STATUS: operational

TYPE: rapid prototyping

COST: High

ADVANTAGES

- contains on-line help
- supports multiple input techniques (i.e., voice and text picture primitives)
- contains a relational database for graphical entity storage and retrieval
- builds prototypes that employ various input devices (e.g., mouse, graphics tablet, voice recognition systems)

DISADVANTAGES

- "erase" command is ambiguous in programming the dynamic prototype
- command language oriented
- cumbersome user interface

SOURCE

Engineering Applications Laboratory
TRW DSG
1 Space Park
Redondo Beach, CA 90278
213/535-7668

REFERENCES

Wong, & Reid, 1982
Jensen, 1987

COMMENTS

TOOL NAME: LAYGEN (LAYout GENerator) **Aviation Related?** no **Record #** 16

DESCRIPTION

LAYGEN is a computer program for designing instrument panels where the operator is mainly standing. Through 2 major modules, alternate ergonomically sound instrument panel layouts are constructed. The first module looks at the panel as a collection of functional groups of displays and controls with interrelationships. The second module operates under the same principles as the first, but with the addition of free units (displays or controls that are not part of any group). Both modules are construction type in that the units are placed sequentially on an initially blank panel. Each panel is divided into 3 sections for placing controls; these sections are an inclined top panel, a vertical middle panel, and an inclined bottom panel. The overall physical dimensions and shape of the panel are defined by the system. In defining the panel, the system considers the anthropometric and visual characteristics of at least 90% of males and females.

REQUIREMENTS

INPUT REQUIREMENTS

- units defining each functional group
- sequence of use among the functional groups
- unit functional links, physical characteristics of each unit (area)
- task numbers
- criticality ratings and clearance requirements (to establish clearances around units
- task numbers of simo controls

OUTPUTS

- echo check of user input data
- complete layout of the panel with units assigned, clearances, and nonutilized areas
- coordinates of centroids of each unit displayed through a 2-D cartesian-coordinate system
- information on the sequence of task placement
- information on the effectiveness of the system in meeting user requirements

RESOURCE REQUIREMENTS

- uses FORTRAN IV on a mainframe
- UNIX
- IBM
- CDC 6600

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** design

ROLE
• control rooms of chemical and nuclear power plants • control rooms of refineries • power distribution networks

TYPE graphic

CLASS
• panel design

STATUS operational

COST Moderate

ADVANTAGES

• panel arrangement and layout is based on heuristic rules which are based on 11 principles of good human factors engineering design practice

DISADVANTAGES

• may take several iterations
• not designed for seated operators

SOURCE

B.M. Pulat and M.A. Ayoub
North Carolina State University
Raleigh, NC 27650

REFERENCES

Jones, et.al., 1982

COMMENTS

NAME STELLA (Structural Thinking, Experimental Learning Laboratory with Animation) **Aviation Related?** no **Record #** 17

DESCRIPTION

... designed to help you improve your thinking and learning capability. With this program, you can build detailed models of physical and social systems on ... evaluation. It is especially effective for exploring the dynamics of complex interrelationships. STELLA allows a designer to build a model as a structural ..., piece by piece, then simulate it to investigate the overall effects of what is being tested. The designer builds the system and STELLA integrates the underlying ...ematics.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• hypotheses about how a system is configured	• animated diagrams • plotted graphs • tables of numerical data • animated components of the structural diagram in the diagram window-as the program runs, stock boxes fill up or empty to show changes in stock quanitites over time	• Macintosh

CLASSIFICATION

PHASE Pre-con, CE, D&V, FSD, P&D, PI

APPLICATION advanced **ACTIVITY** analysis

ROLE • science • engineering • manufacturing • marketing • project management • planning and administration

TYPE functional model

CLASS • FEA

STATUS operational

COST Moderate

ADVANTAGES

- powerful tool for evaluating real-world problems, considering alternatives, obtaining meaningful solutions
- plots can be stepped while being drawn with the pause or stop menu commands
- can be integrated with Powermath for complex mathematical computation
- well written manual

DISADVANTAGES

- limited capability for handling complex mathematical equations
- standard Macintosh clipboard is missing, so copying and pasting is difficult
- thoroughly copy protected so it cannot be installed on ram disks or hard disk drives
- manual is missing a composite listing of the tools and their functions
- takes a lot of time and study to use correctly
- if improperly utilized, it may lead to confusion and actually hamper learning
- both requires and promotes disciplined thought

SOURCE

High Performance Systems
13 Dartmouth College Hwy.
Rte. 1, Box 37
Lyme, NH 03768
603/795-4122

REFERENCES

Jones, 1986
Weigand, 1986
Kirkpatrick, 1987

COMMENTS

TOOL NAME: ADM (A Dialog Manager) | Aviation Related? no | Record # 18

DESCRIPTION

ADM is a system for developing user interfaces. ADM splits an application into two parts. The first part is the interaction handler, which interacts with the user. The second part is the underlying application, which processes user commands and data. After the designer has written the underlying application in a conventional language, he then defines the interface between interaction handler and underlying application in terms of "tasks" which the user can do, and "states" or sets of tasks that are active at one time. The interaction handler is defined in terms of "presentation techniques," and "structuring techniques." The presentation techniques present tasks to the user, and structuring techniques describe the screen layout. ADM aims to reduce the effort required to develop a good interface, rapidly prototype systems in production, promote iterative development, allow for multiple interaction handlers for the same underlying application, provide good quality primitives for constructing interaction handlers, encourage consistency across all interfaces developed with the package, allow different parts of the interface to be developed by different people who are proficient in different areas. ADM consists of a compiler and a run time library.

REQUIREMENTS

INPUT REQUIREMENTS

- the underlying application
- results from front-end analysis

OUTPUTS

- prototype user interfaces

RESOURCE REQUIREMENTS

- ADM runs on Apollo DOMAIN workstations.
- underlying applications are written in FORTRAN, C, or Pascal.

CLASSIFICATION

PHASE: D&V, FSD

APPLICATION: advanced

ACTIVITY: design

ROLE: • rapid prototyping • interfaces

TYPE: user interface management system

CLASS: • UCI design

STATUS: prototype

COST: High

ADVANTAGES

• allows the HF specialist to modify and experiment with an interface independently of the application programmer
• on-line help function
• substantial changes can be made to interfaces in minimal time thereby encouraging iterative development

DISADVANTAGES

• dialog description must be specified before the application can be run

SOURCE

Apollo Computer, Inc.
15 Elizabeth Drive
Chelmsford, MA 01824

REFERENCES

Schulert, et.al., 1985

COMMENTS

TOOL NAME: COUSIN (COoperative USer INterface) — Aviation Related? no — Record # 19

DESCRIPTION

A user interface management system (UIMS) that provides graphical interfaces for a variety of applications based on highly abstracted interface definitions.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• the underlying application • results from front-end analysis	• prototype user interface	• high resolution bit-mapped display • Perq workstation

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** design

ROLE
- developing screen prototypes & user interfaces

TYPE UIMS

CLASS
- UCI design

STATUS operational

COST Moderate

ADVANTAGES

- allows the HF specialist to modify and experiment with an interface independently of the application programmer
- uses a mixed control paradigm
- uses implicit I/O ordering
- ideal for file management, electronic mail, process management, and file transfer

DISADVANTAGES

- insufficient interface for the communication needs of applications requiring finer-grained interaction such as text editors or drawing packages

SOURCE

Defense Agency Research Projects Agency
ARPA Order No. 3597
Monitored by AF Avionics Lab
Contract F33615-81-K-1539

REFERENCES

Hayes, et.al., 1985

COMMENTS

TOOL NAME: CORELAP (Computerized Relationship Layout Planning) — **Aviation Related?** no — **Record #** 20

DESCRIPTION

Corelap is a program designed to develop block plan plant layouts economically. It is a path-oriented logical analysis of the layout program which builds systematically by adding one department upon another until a final layout is achieved. CORELAP performs a logical data reduction in a systematic manner. CORELAP solves the problem of determining the optimum arrangement of equipment and facilities in the job shop situation where the flow of materials follows many paths.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• the relationship chart (REL) • the total number of activities • weights for REL chart entries • area of each activity • maximum ratio of building length to width	• link diagram in block form that is based on the link values specified in the REL chart	• IBM 7090 • any computer with FORTRAN IV capability

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** design

ROLE
- plant layout

TYPE graphic

CLASS
- workspace layout
- facility design

STATUS operational

COST High

ADVANTAGES

- can be converted from a plant layout program to a computerized link analysis program

DISADVANTAGES

- application beyond plant layout to link analysis requires minor adjustments of the input data format

SOURCE

Engineering Management Associates
Room 590
360 Huntington Ave.
Boston, MA 02115

REFERENCES

Cullinane, 1977
Lee, & Moore, 1967

COMMENTS

TOOL NAME: CAPE (Computer Accommodated Percentage Evaluation)   Aviation Related? yes   Record # 21

DESCRIPTION

A Monte Carlo model for generating representative pilot anthropometric features, a link-man model, and an adjustable workspace model for estimating the workspace accommodated percentage.

CAPE offers two options:

1. Exclusion demonstration - determines what percentage of a potential population is excluded from a workspace design with respect to each anthropometric feature entered into the program. This has two features: the exclusion limits component which provides for the entry, storage, and utilization of user-provided standard score limits of anthropometric variables required for exclusion studies, and the Monte Carlo sample generator component which generates quasi-random vectors of standard scores that match a user-provided correlation or correlation square root matrix.
2. Cockpit analysis - determines the percentage of a population that will be excluded from a cockpit design based on the geometric parameters of the workspace. This has four features: a pilot link system, a sample pilot generator component, a component characterizing a seat-cockpit layout, and a cockpit testing component.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• data is input in either batch form or interactively from prepared data files • aircraft parameters • population files	• reach analysis describing the percentage population that can be accommodated • reach obstruction	• the program is written in Super Fortran • IBM 370 • IBM graphics workstation

CLASSIFICATION

PHASE	FSD
APPLICATION	advanced
ACTIVITY	T&E
ROLE	• crew station design • passenger accommodations • detailed design requirements • additional HF analysis
TYPE	graphic
CLASS	• workstation
STATUS	operational
COST	Low

ADVANTAGES

- can be used as both a design and analysis tool

DISADVANTAGES

- in workspace evaluation: it requires special training to use, both from the standpoint of the user and the programmer
- no interactive graphics
- output is strictly numerical
- does not deal with vision
- does not deal with reach interference
- does not address compliance with standards and specifications
- does not accept the anthropometric dimensions of specific individuals as input for man-model construction

SOURCE

Dr. Alvah Bittner
Analytics, Inc.
2500 Maryland Rd.
Willow Grove, PA 19090

REFERENCES

Geer, 1976
Hickey, et. al., 1985
Bittner, 1976

COMMENTS

TOOL NAME: TASCO (Timebased Analysis of Significant Coordinated Operations) **Aviation Related?** yes **Record #** 22

DESCRIPTION

TASCO is a computerized diagnostic tool which enables designers to optimally organize cockpit activities by balancing task complexity and execution time against the estimated time available to perform the task set. TASCO determines the relationships between pilot proficiency, experience, and weapon system complexity to reduce risks resulting from errors of omission and commission. TASCO establishes a timebase along which task elements are organized. This timebase is divided into sections; the tasks for each section must be completed within the alloted time frame for mission objectives to be achieved at an acceptable risk level. The fundamental analytical tool for TASCO is the EDAM (Evaluation, Decision, Action, and Monitoring loop). The loop begins with an evaluation of the situation using data presented via cockpit displays. The second element is the decision made by the pilot based on training, experience, tactical doctrine, and situation awareness. This sets up the action element which is linked to the decision element via man-machine interface components. Finally, each action taken is followed by a monitoring element which evaluates the results of the action in terms of what was desired.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• mission analysis • weapon system configuration • operator behavioral objectives analysis • operational methods and data media analysis • integrated task analysis • task performance-by-mission-phase analysis • task performance-across-mission-phases analysis • training requirements analysis	• measure of task difficulty • probability that task will be successfully completed on initial attempt • penalty imposed on mission effectiveness by low probability of first attempt success • most likely cause of low probability of first attempt success	• mainframe (unknown)

CLASSIFICATION

PHASE: FSD

APPLICATION: advanced **ACTIVITY:** design

ROLE:
- diagnostic tool for avionics operation task structuring

TYPE: timeline, task model

CLASS:
- performance analysis
- T&E

STATUS: operational

COST: High

ADVANTAGES

- standardized time based approach provides objective measures of cockpit workload

DISADVANTAGES

- requires extensive and detailed front-end analysis

SOURCE

Computer Sciences Corporation
Edwards AFB, CA 93523

REFERENCES

Ellison, 1985

COMMENTS

TOOL NAME: ERGONOGRAPHY — Aviation Related? no — Record # 23

DESCRIPTION

Ergonography is a computer graphics tool for visualizing cooperative work involving people and equipment. It utilizes two types of charts. The first is a time chart on which is shown the sequence of task activities performed by specific individuals and equipment. Space charts show physical relationships between people and equipment. Ergonography is an aid for systems engineers from a human factors point of view. It presents people and equipment in extended systems working together.

REQUIREMENTS

INPUT REQUIREMENTS

- sequence of activities
- environmental parameters

OUTPUTS

- time chart
- space chart
- wall charts showing what the system being studied will produce

RESOURCE REQUIREMENTS

- Apple 32-bit systems (Macintosh)

CLASSIFICATION

PHASE	FSD
APPLICATION	advanced
ACTIVITY	design
ROLE	• business-office • publishing • legal • medical
TYPE	graphics
CLASS	• facility design
STATUS	proprietary
COST	Low

ADVANTAGES

- charts are easily revised to reflect new understanding or alternative approaches
- graphic orientation does a good job of illustrating concepts, encouraging discussions, and providing insights
- forces designers to think in terms of people in systems not just equipment

DISADVANTAGES

- overly simplistic, provides no quantifiable data
- not documented

SOURCE

John Holly and Company
4350 W. 136th St.
Hawthorne, CA 90250

REFERENCES

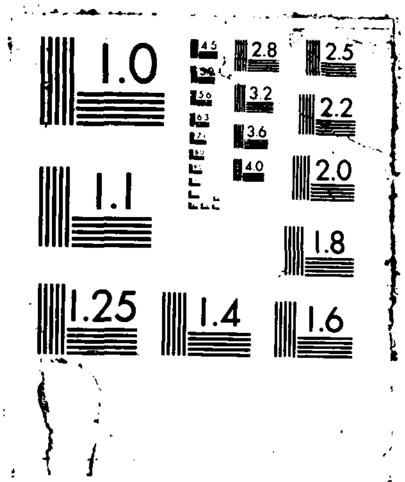
Brecht, et.al., 1985

COMMENTS

...is proprietary, but will become marketable if enough interest in it is generated.

AD-A189 390 ADVANCED HUMAN FACTORS ENGINEERING TOOL TECHNOLOGIES 2/3
(U) CARLOW ASSOCIATES INC FAIRFAX VA S A FLEGER ET AL.
20 MAR 87 DAAA15-86-C-0064

UNCLASSIFIED F/G 23/2 NL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TOOL NAME: MENULAY | Aviation Related? No | Record # 24

DESCRIPTION

MENULAY is an interactive user interface management system with an innovative approach to the design of computer programs. Using MENULAY, programmers can construct and refine software interfaces, interacting with the computer through intuitive gestures. This powerful and flexible system is designed to meet the needs of poeple who are familiar with computers, but who nevertheless need or wish to use them. The system has two components. First, it has a set of tools to support the design and implementation of interactive graphics programs, and second, it has a run-time support package which handles interactions between the system and the user and provides facilities for logging user interactions for later protocol analysis. MENULAY is designed to enable the user interface designer to specify rapidly and naturally the graphical and functional relationships within and among the displays making up a menu-based system. It enables the designer to define user interfaces which are made up of networks of menus.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• results of front-end analysis	• high level code which can be compiled with application specific routines	• PDP-11/45 • written in C • GPAC (device independent graphics package)

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** design

ROLE
- UIMS

TYPE rapid prototyping

CLASS
- UCI design
- rapid prototyping

STATUS operational

COST Moderate

ADVANTAGES

- supports the design of interactive graphics programs (i.e., direct manipulation user interfaces)
- can be used independently of the application programmer to rapidly specify naturally the graphical and functional relationships within and among the displays making up the menu-based system
- has "novice" and "expert" levels

DISADVANTAGES

- limited to the design of menu-based dialogues
- not as powerful or sophisticated as the FLAIR user interface dialogue design tool

SOURCE

Computer Systems Research Group
University of Toronto
Toronto, Ontario
Canada M5S 1A4

REFERENCES

Buxton, et.al, 1983

COMMENTS

TOOL NAME: ASSET (Acquisition of Supportable Systems Evaluation Technology) — Aviation Related? Yes — Record # 25

DESCRIPTION

ASSET is a technology package consisting of computerized tools and procedures for evaluation of the impact of weapon system design on human resources and life cycle cost. ASSET encourages the early coordination of design, logistics support, and operational concepts so that their mutual influence may result in a cost-effective supportable system. ASSET contains six computer models and eight procedures: program definition analysis, consolidated database development, integrated task analysis, maintenance action networks, logistic resources assessment, comparability analysis, lifecycle cost assessment, design option decision trees. ASSET models: reliability and maintainability model, reliability and maintainability cost model, training/aiding matrix model, page estimating model, training requirements analysis model, personnel availability model, logistics composite model, expected value model.

REQUIREMENTS

INPUT REQUIREMENTS

- weapon system program management plan
- operational readiness schedule
- system ownership cost data
- human resource considerations
- systems tasks
- task requirements
- maintenance functions
- logistics resource functions
- reliability data
- maintainability data

OUTPUTS

- tradeoff analyses based on reliability and maintainability parameters
- life-cycle cost hierarchy
- quantity and type of shop technical manuals
- analysis of training requirements
- projections of the number of personnel with specialty codes needed at future dates
- assessment of maintenance, manpower, and expert equipment requirements

RESOURCE REQUIREMENTS

- CDC CYBER system
- FORTRAN

CLASSIFICATION

PHASE Pre-con, CE, D&V

APPLICATION advanced **ACTIVITY** analysis

ROLE
- network analysis
- task analysis

TYPE logistic model

CLASS
- comparability
- FEA
- TA
- Maintenance analysis

STATUS operational

COST Moderate

ADVANTAGES

- complements the logistics support analysis (LSA) process as defined in MIL-STD-1388
- presents detailed comparisons of configuration alterations in terms of cost and resource requirements
- excellent documentation available

DISADVANTAGES

- none identified

SOURCE

US Air Force HRL
Brooks, TX 78235

REFERENCES

Heasly, 1986
Liberati, et.al., 1985

COMMENTS

TOOL NAME: DAP (Display Analysis Program) **Aviation Related?** no **Record # 26**

DESCRIPTION

DAP is a tool for use in evaluating and redesigning alphanumeric displays, especially CRT displays. It can be used to evaluate an already existing system for modification, or as a design tool for prototype tools. The program makes quantitative predictions about the display's usability based on the results of extensive research with a wide variety of display formats. The user creates a file that contains a literal representation of the display to be analysed. DAP reads this file, then performs a series of quantitative analyses on that file to characterize the display format. The results are presented along with appropriate suggestions for how the display might be improved.

REQUIREMENTS

INPUT REQUIREMENTS

- a file that contains a literal representation of the display to be analyzed
- an ASCII file of the data to be analyzed may be transferred to the IBM or compatible via any machine

OUTPUTS

- an analysis of the display
- suggestions for improving the display
- analysis of the types of characters contained in the display (uppercase, lowercase, digits, symbols)
- the % of the total # of characters that each type of character represents
- the overall density of screen characters
- a density map; layout map
- maximum local density value
- average local density value for all characters
- predictions of the groups of characters on the screen that a person would see
- group map; the total # of groups
- list of individual groups, the number of characters in each, and the visual angle in degrees that each group subtends
- maximum visual angle subtended by a group
- average visual angle for all groups
- total # of items, # of different rows & columns, corresponding vertical & horizontal complexities
- overall density
- average local density
- # of groups
- average visual angle subtended by groups
- total layout complexity

RESOURCE REQUIREMENTS

- IBM PC or compatible with at least 256K of memory running DOS 2.0 or a later version

CLASSIFICATION

PHASE D&V, FSD, PI,

APPLICATION advanced **ACTIVITY** T&E

ROLE
- CRT displays

TYPE rapid prototyping

CLASS
- display evaluation
- UCI design

STATUS operational

COST Moderate

ADVANTAGES

- can be used as a design or analysis tool
- provides an objective and verifiable measure of display density
- validated

DISADVANTAGES

- system specific (cannot analyse Macintosh display without converting it to IBM, etc.)
- limited to alphanumeric displays only
- no graphics

SOURCE

TST (Tom Tullis)
27786 Abadejo
Mission Viejo, CA 92692
The Report Store

REFERENCES

Tullis, 1983
Tullis, 1986

COMMENTS

TOOL NAME: SIEGEL-WOLF Aviation Related? no Record # 27

DESCRIPTION

Siegel-Wolf is a model that simulates task performance of operators in groups of 1-3, 4-20, and 20-99. The model is intended to identify areas of operational overload. Stress is viewed as a basic component of overload. In the course of a simulation, the time that is required to complete a task is drawn pseudo-randomly from a distribution (normal, poisson, Weiball).

Flow of simulation:

- operator encounters a task to perform
- task urgency computed (time remaining to complete task sequence)
- stress computed (as a function of urgency)
- task execution time drawn from distribution
- probability of successful task completion drawn randomly from a distribution
- data tabulated and stored
- repeated until all tasks are performed
- repeated until all iterations are performed
- results reported

REQUIREMENTS

INPUT REQUIREMENTS

- mission parameters
- time available to complete tasks
- operator characteristics (speed, stress thresholds, motivation, etc.)
- task characteristics (sequence, essentiality, precedences, execution time)

OUTPUTS

- mission time distributions and mission success distributions as a result of updated mission simulations with outputs dependent on pseudo-randomly drawn inputs
- total time expended
- peak stress encountered during the simualtions
- final stress encounted
- probability of task success
- average waiting time (for another operator to complete a task)
- number of subtasks ignored
- number of tasks not successfully completed
- task sequence (or mission success) probability (successful task sequences/total task sequences)

RESOURCE REQUIREMENTS

- FORTRAN

CLASSIFICATION

PHASE D&V, FSD

APPLICATION advanced **ACTIVITY** analysis

ROLE
- predict the performance of operators in groups

TYPE task model, workload

CLASS
- performance analysis

STATUS operational

COST High

ADVANTAGES

- partially validated
- simulates crew tasks performed simultaneously

DISADVANTAGES

- provides only a gross estimation of crew system performance
- limited to cockpit evaluation

SOURCE

Office of Naval Research (ONR)
800 North Quincy St.
Arlington, VA 22217

REFERENCES

Geer, 1976
Baker, 1979

COMMENTS

Program has been revised under model called MMSS (Man-Machine Stochastic Simulation). Improvements include: a) crew size expanded, b) # of operator action types increased from 4 to 7, c) multiple action paths can occur at any point other than just two alternatives, d) effects of flight turbulence have been added, e) computation of time to perform all remaining essential action has been added.

TOOL NAME: CGE/BOEMAN (Crewstation Geometry Evaluation/Boeman) Aviation Related? yes Record # 28

DESCRIPTION

CGE/BOEMAN is a computerized man-model with 23 joints. CGE/BOEMAN is used to evaluate the reach and vision of seated aircrew members. The dimensions of the model are based on 50th percentile male anthropometric data. The model may be represented as a 2-D link-man or as a 3-D figure with geometric solids as enfleshments. When assessing reach capability, CGE/BOEMAN incorporates both environmental constraints like harnesses and belts, and physical constraints like joint maneuverability. Once the final task position for reach has been found, visual analyses are conducted with CGE/BOEMAN. Compliance checks between military standards/specifications and crewstation items can be completed with the package.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• crewstation geometry • crew member anthropometry • sequence of tasks to be performed • controls data • eye reference points data • output from the CAD model of CAFES may be used as partial input	• list of body segments and crewstation components which interfere with reach and vision • crewstation items which do not comply with specific military standards • graphical illustrations of the man and workplace models • punch cards which must then be entered in as input for the next stage	• written in FORTRAN IV (makes it computer specific) • runs on CDC 6600 computer only

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** design, T&E

ROLE
- man-modeling and environment modeling

TYPE man-model, graphic

CLASS
- reach
- vision
- panel design
- workstation

STATUS operational

COST High

ADVANTAGES

- powerful and relatively complete interference analysis technique
- alternative percentiles for the man-model may be represented by scaling the body segment lengths accordingly

DISADVANTAGES

- unavailable either commercially, or through developers
- obsolescent in its batch input/output and off-line graphics
- the body depths and breadths are fixed at the 50th percentile point
- not transportable to any other computer system

SOURCE

Dr. Georg Frisch
Naval Air Development Center
Warminster, PA 18974

REFERENCES

Hickey, et. al., 1985
Baker, et. al., 1979
Frisch, 1986
Geer, 1976

COMMENTS

obsolete-updated in BIOMAN

TOOL NAME: HF-ROBOTEX (Human Factors-Robotics Expert System)　　Aviation Related? yes　　Record # 29

DESCRIPTION

HF-Robotex is an expert system that is designed to assist in the application of HF principles, data, and techniques to robotics systems design. The expert system will generate specific HF guidelines which are constrained to the knowledge base of Human Factors Engineering and Robotics. The primary function of the system is to allow the user (robotics oriented engineer or HF engineer) to conduct a fast, efficient, and cost effective search of the knowledge base.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• formulate a query as to the specific RD problem by interacting with the inference engine of the system	• guidelines/criteria which are called up from the knowledge base in which they are stored	• IBM PC and compatibles • IBM mainframes

CLASSIFICATION

PHASE	FSD	CLASS	• robotics
APPLICATION	advanced	ACTIVITY	design
ROLE	• robot design	STATUS	operational
TYPE	expert system	COST	Low

ADVANTAGES

- can be used either by an HF engineer or a robotics engineer
- provides a "first-step" for integrating HF with robotics installations

DISADVANTAGES

- has not been validated

SOURCE

White Oak Laboratory
Naval Surface Weapons Center
Robotics and Development Laboratory
10901 New Hampshire Ave.
Silver Spring, MD 20903-5000

REFERENCES

McGuinness, et. al, 1986

COMMENTS

TOOL NAME: GRASP (Graphical Robot Applications Simulation Package) | Aviation Related? no | Record # 30

DESCRIPTION

GRASP is designed to improve the safety features within a robot installation. It uses a data structure similar to SAMMIE model and simulate industrial robot systems. An engineer can improve his overall system and workplace design through CAD techniques. GRASP allows the designer to position the major components of the robot installation so that component interactions are fully considered before decisions on overall layout are made. From here GRASP provides the engineer with data that allows progressively more detailed analysis of safety features including examination of robot "operating zones" and "maximum reach envelopes," guarding requirements, models of how man would interact with the robot, and the identification of potential trapping points.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• workplace layout • robot component parts	• data that allows a progressively more detailed analysis of the safety features: robot operating zones, and maximum reach envelopes • models of how man would interact with the robot • identification of potential trapping points	• IBM PC and compatibles • IBM mainframes

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** design

ROLE
- safety in robot installations

TYPE CAD

CLASS
- robotics
- reach

STATUS operational

COST Low

ADVANTAGES

- allows component interactions to be fully considered from a safety perspective before decisions on overall layout are made

DISADVANTAGES

- has not been fully validated

SOURCE

Department of Production Engineering and Production Management
Nottingham University
Nottingham, England

REFERENCES

McGuinness, et. al., 1986

COMMENTS

TOOL NAME: CADAM/ADAM (Anthropometric Design-Aided Mannequin) & EVE (Ergonomic Value Estimator)   **Aviation Related?** yes   **Record # 31**

DESCRIPTION

CADAM is a tool for generating 2D engineering drawings that may be viewed from the angles: the front, side, and plane. ADAM & EVE were later added to CADAM to enable the system to assess human access, reach, and working postures. The male and female figures represent the 5th, 50th, and 95th percentiles but may be scaled to any percentile in either individual segments or as whole figures. The figures are placed in the CADAM environment in specific positions such as kneeling, standing, prone. Body segments may be manipulated to fit the figure into any specific environment.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• male and/or female figure • percentile range of the figure(s)	• fit assessment • reach from different working postures	• CAD/CAM screen • IBM PC and compatibles • IBM mainframes

CLASSIFICATION

PHASE D&V, FSD

APPLICATION advanced **ACTIVITY** design

ROLE
- technician access to equipment during operation and maintenance

TYPE CAD, man-model

CLASS
- workstation
- reach

STATUS operational

COST Moderate

ADVANTAGES

- figures displayed in top, side or, frontal views
- utilizes multiple input mediums (mouse, lightpen, graphics tablet)
- close-up mode to facilitate freedom of movement determination for confined workplaces

DISADVANTAGES

- no joint movement constraints
- all assessments conducted visually
- neither analytical routines nor numerical output are featured
- worker vision is not assessed
- limited to 2-D problems

SOURCE

CADAM, Inc. a wholly owned subsidiary of Lockheed
Lockheed Missles & Space Co.
Box 504
Sunnyvale, CA 94086

REFERENCES

McGuinness, 1986
Hickey, et. al., 1985

COMMENTS

TOOL NAME: KADD (Knowledge Aided Display Design) **Aviation Related?** yes **Record #** 32

DESCRIPTION

KADD was designed to facilitate display design efforts in computer generated displays, especially aircraft cockpit displays. The KADD concept is composed of four primary modules: 1) Function and Task Analyzer-provides a mechanism for defining to the KADD the information requirements of the aircrew, 2) Graphics/Display Editor-the means for generating the actual display formats, 3) Human Factors Knowledge Database, 4) Simulator/Animator. The KADD runs on a high-performance interactive computer graphics workstation.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• pilot's actions • node data • display editor • manipulate display elements • upfront analysis shell	• display format itself • screen dump	• Apollo 550 • Apollo operating system • Apollo database managemnt system • Apollo 2-D graphics library • written in C, LISP

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** design

ROLE
- aid in designing computer generated displays

TYPE expert system

CLASS
- display design

STATUS Parts 3,4 are complete; Parts 1,2 are prototypes

COST Low

ADVANTAGES

- menu driven interactive input system
- domain independent

DISADVANTAGES

- not validated
- limited to design of single displays
- physical and ergonomic relationships among multiple display is not currently available

SOURCE

NASA-Langley Research Center, and Search Technologies of Norcross, GA.
Owned by COSMIC
Geogria Institute of Technology
Atlanta, GA 30332

REFERENCES

Abbott, 1986
Frey, 1986

COMMENTS

Scheduled completion date, April 1987

TOOL NAME: CAFES (Computer Aided Function Allocation Evaluation System) Aviation Related? yes Record # 33

DESCRIPTION

CAFES is an integrated system of computer models which logically progress from the early concept formulation phase through crew station design to the final test and evaluation of the completed system. It is a design support system based on human engineering methods, computer aids, human performance data, and a data management system. CAFES consists of a set of submodels working in conjunction with a data/information management system. These submodels are FAM (Function Allocation Model), WAM (Workload Assessment Model), CAD (Computer-Aided Crewstation Design Model), and CGE (Crewstation Geometry Model).

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
Please refer to FAM, WAM, DMS, CGE, CAD.	Please refer to FAM, WAM, DMS, CGE, CAD.	• CDC 6600

CLASSIFICATION

PHASE CE, D&V, FSD

APPLICATION advanced **ACTIVITY** analysis, design

ROLE
- crew station design

TYPE family of tools

CLASS
- function allocation

STATUS operational

COST High

ADVANTAGES

- integrated concept which allows for the efficient exchange of data between models as well as the use of common data
- can be used throughout the systems development cycle

DISADVANTAGES

- limited to mainframe computers which curtail widespread use

SOURCE

Developed by Boeing Company for the Navy
Boeing Company
Box 1470
Huntsville, AL 35805

REFERENCES

Geer, 1976
McGuinness, 1986
Baker, 1979

COMMENTS

TOOL NAME: FAM (Functional Allocation Model) | Aviation Related? yes | Record # 34

DESCRIPTION

FAM is one of the 5 modules in CAFES. It is designed to identify and organize system functions, analyze and rank order various functional allocation concepts, analyze and output data for the preparation of Operational Sequence Diagrams. The steps FAM goes through are to identify constraints on allocation (conventions, economics); identify or estimate level of system automation; identify functions best performed by men or machines; and for functions allocated to men, establish a taxonomy of related functions. Two procedures of FAM are the Mission Evaluator, which computes mission reliabilities of allocation schemes, a gross workload measurement of each crew member and man-machine task reliabilities, and Procedure Generator, which derives data for the development of operational sequence diagrams and provides procedure statistics for allocation schemes.

REQUIREMENTS

INPUT REQUIREMENTS

- action mode (channel activity, tactile, visual) average operator reliability for a nominal task time
- earliest task start time during a mission
- task reexecution time for interrupted tasks
- latest task start time
- machine reliabilities
- mission objectives - series of dependent tasks (e.g.,target acquisition)
- mission scenario times (time based)
- mission start time
- mission stop time
- scenario events
- nominal task execution times
- number of task repetitions
- operator reliability (per task)
- task priority (task interruptability)
- reliability curve data
- task reliability weights (relates task importance)
- RNO-remaining number of Opportunities to execute a task (as a function of time units until latest start time)
- pulse constraints (precedents to task execution)
- situations during mission (equipment malfunction, etc.)
- task names

OUTPUTS

- reliability of mission (total mission)
- reliability of mission objectives
- crew members workload estimation
- task reliability (redundant man and machine reliabilities)
- percent of tasks completed and interrupted
- percent of mission time that tasks were being performed simultaneously

RESOURCE REQUIREMENTS

- CDC 6600

CLASSIFICATION

PHASE CE, D&V, FSD

APPLICATION advanced **ACTIVITY** analysis

ROLE
- determining whether a function should be allocated to man or machine

TYPE task model

CLASS
- function allocation
- functional analysis
- procedures design

STATUS operational

COST High

ADVANTAGES

- identifies specific areas where allocation modifications are required

DISADVANTAGES

- major assumptions are required (particularly concerning equipment reliability) for very early implementations of the model

SOURCE

Developed by Boeing Company for the Navy
Boeing Company
Box 1470
Huntsville, AL 35805

REFERENCES

Baker, 1979
Heasly, 1986

COMMENTS

TOOL NAME: WAM (Workload Assessment Model) Aviation Related? yes Record # 35

DESCRIPTION

WAM is an element of CAFES that uses a timeline of mission tasks to identify operator workloads. With WAM, the effects of operator workload due to crew function allocations can be estimated early in the system development. WAM is designed to enable periods of potential operator overload to be identified so that the appropriate measures can be taken to reduce the overload.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• mission profile and scenario • mission phase chart • tasks to be performed and task time for each mission phase • mission phase timeline • identify channels used for each task (visual, manual, cognitive, auditory, verbal) • task data	• average channel workload for each, and combined channels • sequenced list of task start time, duration time and end time • shifted tasks and amount of time a task was shifted • system activity times (system activity defined by subsystem active time, and percentage of activity for total mission time) • list of tasks contributing to overload when threshold is surpassed • workload for each channel • workload for combined channels • workload standard deviation for each and combined channels over total mission time	• CDC 6600

CLASSIFICATION

PHASE D&V, FSD

APPLICATION advanced **ACTIVITY** analysis

ROLE
- identifies periods of operator overload

TYPE task model

CLASS
- FEA
- workload

STATUS operational

COST High

ADVANTAGES

- presents both tabular and statistical summaries of workload

DISADVANTAGES

- none identified

SOURCE

Developed by Boeing Company for the Navy
Boeing Company
Box 1470
Huntsville, AL 35805

REFERENCES

Baker, 1979

COMMENTS

TOOL NAME: HOS (Human Operator Simulator) — Aviation Related? yes — Record # 36

DESCRIPTION

HOS simulates information absorption and recall, mental computations, decision making, anatomy movements, control manipulations, and relaxation. HOS simulates operator procedures by acquiring the data necessary, making a decision, and supplying appropriate steps to follow. HOS can, in some situations, activate a subsystem if insufficient data is supplied. HOS was developed to assess system operability at early stages of the system design process. HOS enables a design team to investigate system operability under a variety of missions, crewstation designs, operator characteristics, and environmental conditions without incurring the full-costs and delays of building special-purpose hardware and training experimental operators. HOS is implemented as three connected computer programs: HAL, HOS, and HODAC. HAL is the HOPROC (processing lang.) Assembler and Loader, HOS is the Human Operator Simulator, and HODAC is the Human Operator Data Analyzer and Collator.

REQUIREMENTS

INPUT REQUIREMENTS

HAL input:
- mission scenario data
- detailed task data
- control and display locations
- method of control activation
- display information
- operator procedures
- hardware procedures
- beginning/nominal system and operator status
- information absorption times

HOS Component Program input:
- HAL outputs
- user supplied specifications of device and operator characteristics

HODAC input:
- HOS outputs
- types of analysis desired
- time periods
- displays/controls of interest

OUTPUTS

HAL output:
- modified FORTRAN code for Operator and Hardware Functions

HOS output:
- a detailed timeline record of simulation events
- human behavior data

HODAC output:
- analyzed human behavior
- timeline analysis (the snapshot interval of time)
- channel loading within each snapshot interval
- channel activity statistics related to each device
- device usage time of specific actions (time spent moving, manipulating, recall, etc. for each device)
- link analysis (transition times, link frequencies)

RESOURCE REQUIREMENTS

- HOPROC-Human Operator Procedure Language
- FORTRAN
- HAL-HOPROC Assembler and Loader
- CDC 6600
- In the design phase of adaption to PC

CLASSIFICATION

PHASE CE, D&V, FSD

APPLICATION advanced **ACTIVITY** analysis

ROLE
- operational military and nonmilitary crewstations
- the assessment of system operability at early stages of the system design process

TYPE man-model

CLASS
- workload
- performance analysis

STATUS operational

COST High

ADVANTAGES

- simulates both human (perceptual, motor, and cognitive functions) and machine operating characteristics

DISADVANTAGES

- batch input (control card language) is slow and cumbersome

SOURCE

US Naval Air Development Center
Warminster, PA 18974

REFERENCES

Baker, 1979
DoD-HDBK-XXX, 1986

COMMENTS

TOOL NAME: CAFES-CAD (Computer Aided Function Allocation Evaluation System-Computer Aided Design) **Aviation Related?** yes **Record #** 37

DESCRIPTION

A model of CAFES developed to assist in designing crew station configurations (cockpit) consistent with mission requirements, military standards, cost and technical constraints and considerations. CAD has 3 classes of functions: crewstation design development, crewstation design analysis, and graphic functions. CAD functions include: geometry description for computer storage/retrieval, proportionate scaling (expansion/contraction) of defined crewstation geometry, customized changes (tailoring) in geometry of computer stored configurations, interference analysis between crewmember escape and a specified crewstation, vision analysis, reach analysis, computer generated graphic views of crewstation cross sections.

REQUIREMENTS

INPUT REQUIREMENTS

- a defined workspace: instrument groups, control panels, controls (reference point, shape, etc.), physical boundaries, reach envelopes, scale factors (to modify sizes of workspaces), eye reference points, transparent and opaque surfaces

OUTPUTS

- escape envelope penetrators
- external vision capabilities
- derivations in reach distances between reach limits and cockpit locations for both hands and feet
- visual distances from design eye reference point to point on a panel surface
- vision plane intersection

RESOURCE REQUIREMENTS

- CDC 6600

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** design

ROLE • cockpit design • emergency escape evaluations

TYPE CAD

CLASS
- workstation design
- panel design
- reach analysis
- vision analysis

STATUS op. ational

COST High

ADVANTAGES

- can be used for both design and analysis

DISADVANTAGES

- limited to cockpit configurations

SOURCE

Naval Air Development Center
Warminster, PA 18974

REFERENCES

Baker, 1979

COMMENTS

Specifically designed for aircraft systems but may be applicable to others

TOOL NAME: DMS (Data Management System)

Aviation Related? yes

Record # 38

DESCRIPTION

DMS is a component of CAFES. It provides baseline data for all other CAFES subsystems. DMS has three purposes, the first is data maintenance (input, editing, storage), the second is as an interface with the other submodels (in terms of data transfer), and the third is output data direction. DMS is composed of an editor which stores, inputs, and edits data, a user interface which accepts directions for data manipulation, an executive which implements other submodels and prepares data files, and a report generator which directs output as specified by the user. DMS is essentially the medium by which a CAFES user implements the other submodels and maintains a system database. The objectives of the DMS are to provide rapid access to standardized data relative to operational and/or proven system concepts for use by both the CAFES submodels and the crew systems designer, to allow for amalgamation of data commensurate with a given level of system definition, to allow postulation of additional levels of system definition in a rapid and easy manner, and to provide an information storage scheme sufficiently general to handle the diverse data requirements of the submodels. The major functions performed by the DMS are data input and storage, file modification, CAFES executive, error diagnostics, report generation.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• data input	• error diagnostics • report generation	• CDC 6600

CLASSIFICATION

PHASE	FSD	CLASS	• data integration
APPLICATION	advanced	ACTIVITY	analysis
ROLE	• data maintenance • data transfer • data output among the tools of CAFES	STATUS	operational
TYPE	database	COST	High

ADVANTAGES

• none identified

DISADVANTAGES

• none identified

SOURCE

Developed by Boeing Company for the Navy
Boeing Company
Box 1470
Huntsville, AL 35805

REFERENCES

Baker, 1979

COMMENTS

TOOL NAME: MAWADES (Multi-man MAchine Work Area Design Evaluation System) Aviation Related? yes Record # 39

DESCRIPTION

MAWADES is a computerized design tool for a human factors specialist. It has been developed for designing the workspace of a crew for command, communications, and control activities at sit-stand duty. MAWADES consists of 4 modules. The first is WOSTAS which accepts mission oriented task requirements, and scheduling and line balancing concepts, generates alternate scheduling schemes of tasks to workstations. Second, the WORG module generates ergonomically sound layouts of the workstations within the workspace. Workstations are laid out according to calculated link values between them. The third module is WOLAG; it has been designed to generate panel layouts at each workstation. Displays and controls are laid out sequencially on a panel based on system functions and operational relationships between panel components. The fourth module, SAINT, is for dynamic evaluation of suggested alternative designs.

REQUIREMENTS

INPUT REQUIREMENTS

- input for WOSTAS
- input for WORG
- input for WOLAG
- input for SAINT

OUTPUTS

- WOSTAS output
- WORG output
- WOLAG output
- SAINT output

RESOURCE REQUIREMENTS

- uses FORTRAN IV on a mainframe
- UNIX
- IBM
- CDC 6600

CLASSIFICATION

PHASE D&V, FSD

APPLICATION advanced **ACTIVITY** design

ROLE
- design of workstations for sit-stand C3 duty

TYPE family of tools

CLASS
- panel design
- workspace layout
- crew station design

STATUS operational

COST High

ADVANTAGES

- approaches systems design from a "systems" viewpoint
- when all 4 modules are used in succession, major design problems can be solved in 1-2 days
- can be used for designing both seated and standing workstations
- interactive system configuration permits near real-time modification and updates

DISADVANTAGES

- see specific module

SOURCE

Office of Naval Research
800 North Quincy St.
Arlington, VA 22217

REFERENCES

Pulat, 1984

COMMENTS

TOOL NAME: WOSTAS (Workstation Assessor) — Aviation Related? no — Record # 40

DESCRIPTION

WOSTAS is an interactive, computerized model that accepts mission-oriented task requirements. WOSTAS generates alternate scheduling schemes of tasks to workstations through application of scheduling and line balancing concepts. The task allocations consider balancing the degree of physical effort among workstations. The model is designed to study repeated, cyclic task sequences in a multioperator workstation environment.

REQUIREMENTS

INPUT REQUIREMENTS

- the crew mission in network form with tasks and durations
- a time window during which tasks must be completed
- the relative extent of language, intellectual, perceptual, and psychomotor abilities required for each task in the mission network
- fatigue characteristic of each task
- the probabilities of alternative paths and task priority constraints

OUTPUTS

- a complete schedule of tasks among crew members
- performance measures associated with free time at workstations
- ability and fatigue characteristics of assign tasks

RESOURCE REQUIREMENTS

- uses FORTRAN IV on a mainframe
- UNIX
- IBM
- CDC 6600

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** analysis

ROLE • mission effectiveness criteria • detailed design req. • personnel req. info • system ops eval. • HF analysis • HFE data store information

TYPE task model

CLASS
- task allocation
- workload
- procedures

STATUS operational

COST Moderate

ADVANTAGES

- does not assume that each task requires the same types and levels of abilities (e.g. inteligence, perceptual, psychomotor, language) on the part of the operator
- incorporates probabilistic branching to allow operation to assume alternate tasks to prevent bottlenecks
- incorporates a fatigue factor on a 1-10 ratio scale

DISADVANTAGES

- sound employees selection procedures are assumed to ensure that all tasks at a given workstation can be performed by the same worker

SOURCE

Office of Naval Research
800 North Quincy St.
Arlington, VA 22217

REFERENCES

DOD-HDBK-XXX, 1986
Pulat, 1982
Pulat, 1983

COMMENTS

TOOL NAME: WORG (Workspace ORGanizer) Aviation Related? no Record # 41

DESCRIPTION

WORG is part of the Multi-Man-MAchine-Work Area Design and Evaluation System (MAWADES). It is an interactive computer model which prepares the layout of several workstations within a workspace. The relative locations of the workstations are determined after link analysis (visual, voice, and electronic communication) between stations. This model collects evaluative measures on the designs generated. This data may be analyzed by a decision maker to choose the best design.

REQUIREMENTS

INPUT REQUIREMENTS

- total number of workstations
- total number of tasks to be carried out across the stations

Workstation input:
- station numbers and the operator count for each

Task input:
- task number
- area requirement of associated display or control, if any
- criticality rating
- predecessor count, task numbers of preceeding tasks
- successor count, task numbers of successors
- workstation assignment
- sequential link between this task and each successor
- task type

OUTPUTS

Report files:
- a grid layout showing the exact locations of the workstations
- the relative locations of the stations given by the relative arrangement of the station numbers on the final layout
- placement sequence of the workstations on the layout matrix
- total links value-an evaluative measure for the layout obtained

RESOURCE REQUIREMENTS

- uses FORTRAN IV on a mainframe
- UNIX
- IBM
- CDC 6600

CLASSIFICATION

PHASE: FSD

APPLICATION: advanced

ACTIVITY: design

ROLE:
- relative locations of workstations

TYPE: graphic

CLASS:
- workstation arrangements
- facility design

STATUS: operational

COST: Moderate

ADVANTAGES

- extends the single workplace design concept to specifically address the problem of designing multiple workplaces within a workspace

DISADVANTAGES

- link analysis does not consider "sequential" workplace relationships, only "importance" and "frequency" of interrelationships

SOURCE

ONR Contract # N00014-81-C-0320
Office of Naval Research
800 North Quincy St.
Arlington, VA 22217

REFERENCES

Pulat, 1983

COMMENTS

TOOL NAME: WOLAG (Workstation Layout Generator)

Aviation Related? no

Record # 42

DESCRIPTION

WOLAG is a computerized interactive model, designed to prepare panel layouts at each station for sit-stand duty. Displays and controls are laid out sequentially on a panel based on system functions and operator tasks. The physical dimensions of the panel, along with panel sections and angles between sections, are determined after consideration of workspace geometry (anthopometric variables), the visual space (visual field, eye-head movements, etc.), and locational priority zones. The panel's physical features (including the height, length, and partitions) are embedded in the model. This model collects evaluative measures on the designs generated. This data may be analyzed by a decision maker to choose the best design.

REQUIREMENTS

INPUT REQUIREMENTS

General:
- total number of workstations (panels), and the width of each panel

Workstation inputs:
- functional groups of units
-number of such groups at each panel
-group composition (members)
-group type (simo use, sequential use, or free units)
- sequence of use between functional groups, if any
- for each display or control
-area requirement (cm2)
-criticality code
-operational relationship with other units
-clearance code

OUTPUTS

- layout matrix of the instrument panel complete with unit assignments, unused portions
- placement sequence of the units on the panel
- evaluative measures on the designs generated:
-total links value
-average zone deviation
-total zone deviation

RESOURCE REQUIREMENTS

- uses FORTRAN IV on a mainframe
- UNIX
- IBM
- CDC 6600

CLASSIFICATION

PHASE	FSD	CLASS	• panel design • reach • vision
APPLICATION	advanced	ACTIVITY	design
ROLE	• panel layouts	STATUS	operational
TYPE	graphic	COST	High

ADVANTAGES

- criticality codes are similar to the ones used in WORG

DISADVANTAGES

- area data must be in metric units
- anthropometric and visual characteristics used in defining physical dimension are based on 90% of adult US population
  - -sample source unknown
  - -female inclusion in database unknown

SOURCE

ONR contract # N00014-81-C-0320
Office of Naval Research
800 North Quincy St.
Arlington, VA 22217

REFERENCES

Pulat, 1983

COMMENTS

TOOL NAME: OSDS (Operator Station Design System)

Aviation Related? yes

Record # 43

DESCRIPTION

OSDS includes stand-alone mini-computer hardware and PLAID and CAR. The data base consists of Shuttle Transportation System Orbiter Crew Compartment, the orbiter payload bay and remote manipulator, and various anthropometric populations. The system is utilized to provide panel layouts, assess reach and vision, determine interference and fit problems early in the design phase, study design applications as a function of anthropometric and mission requirements, and to accomplish conceptual design to support advanced study efforts.

REQUIREMENTS

INPUT REQUIREMENTS

- anthropometric data
- environmental parameters

OUTPUTS

- panel layouts
- reach assessment
- vision assessment
- obstruction assessment
- fit assessment

RESOURCE REQUIREMENTS

- FORTRAN IV
- CDC Computer Systems
- VAX

CLASSIFICATION

PHASE: CE, D&V

APPLICATION: advanced

ACTIVITY: design

ROLE:
- shuttle layout

TYPE: graphic

CLASS:
- panel design
- reach
- vision

STATUS: operational

COST: High

ADVANTAGES

- interactive system configuration permits near real-time modification and updates

DISADVANTAGES

- partially validated
- database limited to STS orbiter crew compartment and payload bay

SOURCE

NASA
Johnson Space Center
Houston, TX 77058

REFERENCES

Lewis, 1979a

COMMENTS

TOOL NAME: PLAID (Panel Layout Automated Interactive Design) — Aviation Related? yes — Record # 44

DESCRIPTION

PLAID was developed to facilitate the layout and installation stages of displays and controls in spacecraft flight stations. PLAID provides 3-D modeling in a real-time interactive environment. The user can specify tolerance limits when assembling objects. The user can also designate subassemblies or component levels. Objects are displayed in either wire-frame or hidden-line form. Any viewing angle is possible by specifying the 6 3-space coordinates which identify the position being viewed and the design eye point. The user may opt for perspective or isometric projection, along with cutaway views and variable scaling. Future improvements include real-time dynamic display and shaded image capability.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• individual reach data	• clearances and objects in collision	• FORTRAN
	• graphics output	• VAX
		• Tektronix terminal

CLASSIFICATION

PHASE: FSD

APPLICATION: advanced **ACTIVITY:** design

ROLE:
- layout of displays and controls in flight stations

TYPE: CAD

CLASS:
- panel design
- reach
- vision

STATUS: operational

COST: Moderate

ADVANTAGES

- highly versatile tool-used for many applications beyond its original purpose

DISADVANTAGES

- has not been validated
- not truly machine independent
  - graphics display must be a Tektronix 4014 or compatible
  - digitizer tablet must be a Talos

SOURCE

NASA
Johnson Space Center
Houston, TX 77058

REFERENCES

Lewis 1979a
Lewis 1979b

COMMENTS

TOOL NAME: CADET (Computer Aided Design and Evaluation Techniques) **Aviation Related?** yes **Record #** 45

DESCRIPTION

CADET is a collection of computer programs for the analysis, design and evaluation of crewstations. Four programs constitute CADET: reach assessment, workload assessment, display format design, and system simulation. The user has the choice of accessing these programs either directly or through a menu. The reach assessment tool enables users to evaluate crewmember accommodation to the crewstation. The workload assessment tool is provided by the HOS program, and system analysis is performed by the general purpose SAINT simulation program. The built-in anthropometric database is used to evaluate reach within the defined crewstation. CADET uses a common database for all models.

REQUIREMENTS

INPUT REQUIREMENTS

General input:
- crewstation design with relative position of each switch, button, or control input device to the design-eye point
- operator procedures and functions to be performed
- process inputs and outputs
- time to complete each process
- relationships among the processes within the system

Workload assessment input:
- operator procedures and functions to be performed
- hardware procedures and functions
- locations of each of the controls the operator is required to use

OUTPUTS

General output:
- charts showing the percentage of the population which can reach each of the control devices
- workload in percentages of time spent using each hand, foot, and the eyes
- mental effort on a mission basis for each individual operation
- crewstation design formats
- process completion time, waiting time, and resource utilization
- statistics for the entire system and for each process

Reach assessment output:
- the percentage of the population which can reach each of the control devices

Workload assessment output:

RESOURCE REQUIREMENTS

- VAX/VMS Digital Control Language (DCL)
- FORTRAN

CLASSIFICATION

PHASE D&V, FSD

APPLICATION advanced **ACTIVITY** design, T&E

ROLE • mission effectiveness criteria • detained design req • personnel req info • maintenance sys div • sys ops eval • HF analysis • HFE data store info

TYPE CAD

CLASS
- panel design
- reach/vision
- workload
- simulation

STATUS operational

COST High

ADVANTAGES

- user friendly interface (user not required to learn VAX/VMS Digital Control Language)

DISADVANTAGES

- refer to HOS and SAINT

SOURCE

USAF Crew Systems Development Branch
Flight Control Division
WPAFB, OH 45433

REFERENCES

DOD-HDBK-XXX, 1986
Rose, 1986a
Gifford, 1986

COMMENTS

TOOL NAME: CAR (Crewstation Assessment of Reach) Aviation Related? yes Record # 46

DESCRIPTION

CAR is a link man-model and an adjustable workspace model for assessing pilot anthropometric data. Given the workspace model, CAR can compute the percentage of aviators that can be accommodated by that particular workspace (cockpit). Utilizes Monte Carlo Sampling Model (MCSM) procedures, and CAM (Crewstation Analysis Model). CAR allows reach assessment to be approached from two angles. A workstation can be evaluated to see if it will accommodate the selected user population, or to determine the percent of the population that it accommodates.

REQUIREMENTS

INPUT REQUIREMENTS

- workspace model
- anthropometric data on aviators
- physical geometry on seat, canopy, and controls
- position of operator in crew station

OUTPUTS

MCSM output:

- sample aviator anthropometric data-12 randomly generated anthropometric measures for a user specified number of sample aviators-these measures are translated into 19 man-model links

CAM output:

- the percentage of aviators that can be accommodated by that workspace (cockpit).

RESOURCE REQUIREMENTS

- FORTRAN IV
- CDC Computer Systems
- VAX
- IBM

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** CAD

ROLE
- reach studies in the F-4, F-14, F-16, AV8B

TYPE man-model, workspace model

CLASS
- reach evaluation
- panel design

STATUS operational

COST Moderate

ADVANTAGES

- validated
- developed to be machine independent
- can be used to evaluate and design multiple operator workstations having common or shared controls
- extremely versatile- accept up to 50 different control reach point locations based on physical location in space (in reference to SRO) type of body element used to make reach, type of hard grip, type of clothing and whether cross-shoulder belt is locked or open
- menu driven user friendly interface
  - -prompts user
  - -extensive error checking capability

DISADVANTAGES

- CAR - II version can only be used for control stations with limited reach demands where high levels of operator restraint are the rule, CAR - III and IV are less constrained
- reach obstructions and body clearance can't be addressed
- no graphical output
- poor user interface on IBM XT

SOURCE

Analytics, Inc.
2500 Maryland Rd.
Willow Grove, PA 19090

REFERENCES

DOD-HDBK-XXX
Baker, 1979
Morrissey, 1985
Harris, 1982

COMMENTS

Based on CAPE model

TOOL NAME: CHESS (Crew Human Engineering Software System) **Aviation Related?** yes **Record #** 47

DESCRIPTION

CHESS is comprised of 5 modules. The first module is the Flightdeck Configuration Control (FCC) module which manages the control station description data required by the analysis modules. The Instrument Readability Analysis (IRA) and the Crewstation Assessment of Reach (CAR) address purely geometric aspects of the control station design. The Subsystem Workload Assessment Tool (SWAT) and the Time Line Evaluation (TLE) modules estimate physical operator workload in performance specified operating procedures (SWAT) or in the context of an extended operating scenario (TLE).

The FCC contains the operational definition of each task for each operating procedure. IRA calculates for each control station component on each module selected from the FCC database, the physical height required of a marking to make it subtend any chosen visual angle at the eye of an observer positioned at a specified location at the control station. IRA simulates realistic head motion in looking at each selected location using a link-man model of the observer's head and neck which permits horizontal rotation around a shoulder pivot point and vertical rotation around neck and head pivot points. CAR III is used for the assessment of reach in the CHESS package. This version of CAR includes female operators and mixed-sex populations. SWAT is designed to estimate physical operator workload for an operator performing a specified procedure or set of closely related procedures using a control station of a specified configuration. TLE assesses physical operator workload for complete operating scenarios in which one or more operators must perform a sequence of specified operating procedures throughout a prolonged period of operation.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
FCC: • location and description of each control station component • workload-related data for each task in which a component is used	FCC: • document-quality reports detailing the entire control station configuration either at the time of the creation of an FCC database file or from a previously created database file. CAR: • reports documenting both the sample population and the reachability of each control selected for analysis SWAT: • workload estimates along the dimension of visual motion • workload estimates along the dimension of manual motion • for each group or related group of procedures, a task link analysis which reports all sequential task pairs which are required to be performed more than once TLE: • reports which detail the operational time line for all operators • provides a verbal summary of each operator's contribution • summary of the useage of each of the control station's controls and indicators	• Cyber • Cray-1

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** design

ROLE • evaluating transport aircraft flightdeck design • control station design

TYPE workstation model

CLASS • workstation design

STATUS operational

COST High

ADVANTAGES

• workload related data need only be entered once for whole classes of similar conrtrols or indicators
• controls can be grouped in modules such that relocation of a module does not require recomputing the 3-D coordinates of individual components when physical changes are made to the design
CAR - III module permits assessment of female operator population and control stations which demand extremes of reach and minimal restraint

DISADVANTAGES

• limited to aircraft flightdeck design

SOURCE

Boeing Computer Services Company
815 Jadwin Ave.
Box 300
Richland, WA 99352

REFERENCES

Jones, 1982

COMMENTS

Proprietary

TOOL NAME: SWAT (Subjective Workload Assessment Technique) | Aviation Related? yes | Record # 48

DESCRIPTION

SWAT is a simplified rating procedure with a high potential sensitivity. It can handle simultaneous measurement of multiple factors contributing to workload including visual motion and manual motion. Minimal assumptions are required to generate the workload scales. The interval level of measurement permits parametric statistical analysis and comparability across subjects and task. The individual subjects participating in the rating exercises are calibrated by way of a standardized task process from which the test subject's individual rating scale and group norm scale are determined through measurement and scaling analysis. The subjects then participate in the event scoring phase for accomplishment of the experimental task.

The SWAT procedure consists of two parts, a card-set and a rating scale. SWAT consists of a set of scales that breaks workload down into three factors, time load (the amount of time a subject is busy), mental effort load (amount of attention and effort required to complete the task), and psychological stress load (the amount of confusion, anxiety, or frustration which cause a need for greater concentration and determination).

REQUIREMENTS

INPUT REQUIREMENTS

- an individual rating scale
- group norm scale

OUTPUTS

- a prototype analysis of each subject's data
- correlation coefficients to relate each subject to respective prototype groups
- separate analyses of subjects in prototyped groupings

RESOURCE REQUIREMENTS

- any machine with a conjoint analysis program

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** T&E

ROLE • mission effectiveness criteria • detailed design requirements • personnel req. info. • maintenance sys. div. • sys ops eval • HF analysis • HFE data store info

TYPE rating scale

CLASS • workload evaluation

STATUS operational

COST Moderate

ADVANTAGES

- validated
- collection of ratings is simple and efficient
- can be used to examine a procedure or procedures which must be performed in an exacting manner or under strict time constraints

DISADVANTAGES

- card-set to access workload parameters is tedious and time consuming
- card-set analysis requies access to a conjoint computer program

SOURCE

AFAMRL
Workload and Ergonomics Branch
Human Engineering Division
WFAFB, OH 45433

REFERENCES

DOD-HDBK-XXX, 1986
Vidulich, 1985
Jones, et. al., 1982

COMMENTS

TOOL NAME: OWLES (Operator Workload Evaluation System) **Aviation Related?** no **Record # 49**

DESCRIPTION

OWLES is a SAINT based operator workload evaluation system developed for the Precision Location and Strike System (PLSS). It examines information presentation, decision making, and procedures implementation for a menu-driven, interactive computer terminal serving as the PLSS operator console. OWLES uses integrated computer-aided manufacturing definition (IDEF) to analyze the functions the system performs so the SAINT task network can be traced to the system design concept. It provides a simple representation of the human information processing and decision making in response to presented information. It also reflects the amount of mental versus physical effort by tracking how often different kinds of tasks are executed.

REQUIREMENTS

INPUT REQUIREMENTS

- function decomposition to the level of specific keyboard entries and resulting display changes
- estimates or data on individual activity duration and rules (conditional logic) for information processing and decision making
- probabilities of error

OUTPUTS

- information pathways and flow statistics
- times for completing activity sequences
- frequency of each decision outcome
- error counts for data entry and menu selection tasks

RESOURCE REQUIREMENTS

- uses FORTRAN on a mainframe
- UNIX
- IBM
- CDC 6600

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** T&E

ROLE • mission effectiveness criteria • personnel req info • sys ops eval • HF analysis • HFE data store information

TYPE information model

CLASS • workload evaluation

STATUS operational

COST High

ADVANTAGES

• interactive menu driven interface for simplified control

DISADVANTAGES

• none identified

SOURCE

Naval Air Development Center
Warminster, PA 18974

REFERENCES

DOD-HDBK-XXX, 1986

COMMENTS

TOOL NAME: ATB Model

Aviation Related? yes **Record #** 50

DESCRIPTION

The ATB Model was modified from the CALSPAN 3D CVS model to handle Air Force applications such as emergency escape from high altitude aircraft, and restraint during aircraft crashes. The modification includes joint and restraint algorithms and the addition of aerodynamic forces. The program requires extensive data input.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
For simulation of a dynamic event: • the principal moments of inertia, mass • contact surface ellipsoid center and radii • joint locations for each segment segment interaction characteristics for segment-to-segment and segment-to-external structure contacts • joint torques as a function of segment rotation • the type of joint (ball and socket vs. hinged) • the geometric description of the harness • the harness placement on the body • the specification of a common belt/segment elasticity • the external dynamic environment to which the body is exposed (cockpit geometry, seat acceleration)	• time histories of all segment linear and angular displacements • velocities and accelerations • tensile and belt forces of the harness system • contact forces generated • points of contact between body segments and the seat/floor surfaces	• CDC 6600

CLASSIFICATION

PHASE D&V, FSD

APPLICATION advanced **ACTIVITY** design

ROLE • simulations of - G-Force impacts • simulations of ejection from high performance aircraft

TYPE graphic

CLASS • life support

STATUS operational

COST High

ADVANTAGES

• validation of results against experimental data have been favorable
• good for analyzing emergency egress from aircraft
• the size and initial position of the operator may be varied by the program user

DISADVANTAGES

• fails to address physical compatibility such as reach, vision between man and workplace
• doesn't simulate the shoulders as a double mechanism, but as a connected system that doesn't represent the correct freedom of movement
• cannot take actual human data, needs percentile characteristics/measures

SOURCE

US Air Force Aerospace Research Lab
Aerospace Medical Division
Air Force Systems Command
Wright-Patterson AFB, OH 45433

REFERENCES

Hickey, et.al., 1985
Rothwell, 1987

COMMENTS

• modified version of CALSPAN 3D CVS Model
• modification done by the Air Force

TOOL NAME: BIOMAN

Aviation Related? yes Record # 51

DESCRIPTION

The computer graphics program, BIOMAN, evaluates aircrew-cockpit physical compatibility under various operational conditions (maneuvers, carrier landings, ejections, crashes). BIOMAN uses the output of other human factors models for real-time visual analyses and interpretation. BIOMAN is designed to detect potential sources of impact in existing and conceptual crewstations. BIOMAN replicates a monitored motion and analyzes it within the constraints of specific crewstation configurations. The program uses three representations of humans: the ATB Model man (ellipsoid enfleshed), a spherical man-model, and a topological representation developed by Biostereometrics Lab, Baylor College of Medicine. Evaluation of the occupant response and the crewstation may be done simultaneously or individually. The designer may select any viewpoint and perspective of the display. The cockpit/workstation may be evaluated from the perspective of the user's vision by setting the viewpoint to the man-model's eye reference point.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• human dynamic data- the link lengths, joint ranges, segment weights, and initial positions of the occupant model are dictated by the test conditions • track and tower test data (using instrumented dummies) • computer simulation results	• fit assessment • obstructions • force deformations in high G situations like cockpit ejection	CDC 6600 Cyber Univac IBM any 60 bit word machine

CLASSIFICATION

PHASE D&V, FSD

APPLICATION advanced **ACTIVITY** design

ROLE • emergency egress conditions • acceleration profile as determined during ejection tower tests

TYPE man-model, workspace model, graphic

CLASS
- panel evaluation
- visual envelope

STATUS operational

COST High

ADVANTAGES

- looks at humans in terms of force deformation properties-torques
- restraints on joints
- simulates parachute deployment
- variable crewstation
- surfaces can be isolated and contacts can be monitored
- any segment can be driven as long as the forces are known
- anatomical data has been validated by the Naval Biodynamics Lab and is regularly updated
- ejection seat forces have been validated using the tower (for both dummies and humans)
- segments have disassociated connectivity-can jolt one segment and see how the others respond
- simulates restraint systems (belts, harnesses)
- each segment has its own specific force deformations (even the helmets)
- can simulate windblast forces
- can predict crewstation hazards
- anthropometry of the occupant can be easily changed

DISADVANTAGES

- analyses are limited to clearance and emergency egress
- analyses of occupant vision are minimal
- reach is not addressed
- macro view-each segment responds as a segment mass
- highly deformable torso is not true to life
- cannot handle biodynamic center of gravity shifts easily
- doesn't address injury modalities (can't predict where injury will occur, only that an injury is likely
- thorax is not validated
- simulates only one occupant at a time

SOURCE

- originally developed for the Department of Transportation in Washington, D.C.
- developer, Georg Frisch, is now at NADC-Code 6022, Warminster, PA

REFERENCES

Frisch, 1986

COMMENTS

TOOL NAME: BUFORD | Aviation Related? yes | Record # 52

DESCRIPTION

BUFORD is a 15-link man-model developed for use in cockpit design. The model is enfleshed by body and limb outlines, and represents a 50th percentile man. It may, however,be scaled to any size. Clothing and equipment (space suit, helmet) may be drawn on the figure. Any working environment can be built around the man-model. The designer must manipulate the model's limbs and change his body position to evaluate reach and clearance. The program does not have any analytical routines; therefore, success or failure must be determined visually by the designer.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• no information available due to proprietary nature of program	• no information available due to proprietary nature of program	• CDC 6600

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** design

ROLE
- cockpit design

TYPE man-model

CLASS
- workstation desgin

STATUS operational

COST High

ADVANTAGES

- no information available due to proprietary nature of program

DISADVANTAGES

- lacks joint constraints on the man-model
- lacks analytical features like reach, clearance
- does not address vision

SOURCE

Rockwell International
12214 Lakewood Blvd
Downey, CA 90241

REFERENCES

Frisch, 1986

COMMENTS

Rockwell won't release the program commercially or by special permission.

TOOL NAME: CALSPAN 3D CVS — Aviation Related? no — Record # 53

DESCRIPTION

CALSPAN 3D CVS is a biodynamic modeling program that was developed for the Department of Transportation. It is used to study automobile crashes in an effort to predict the human body response and injury resulting from impacts and abrupt accelerations. Multiple occupants/pedestrians may be simulated in a study using CALSPAN 3D CVS. Each man-model has a maximum of 19 joints (ball and socket, and hinged) and 20 segments which are enfleshed with ellipsoids. The segments are restricted by angular limits of motion. Built into the system are simulations for various crash situations such as frontal collision, pedestrian impact, and motorcycle accidents. The system also includes simulations of restraint systems like airbags, lapbelts, and shoulder harnesses. CALSPAN 3D CVS can predict contact forces, even those between body segments. CALSPAN 3D CVS has been validated against a series of sled tests and automobile collisions.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• no information available	• no information available	• CDC 6600

CLASSIFICATION

PHASE FSD, P&D, PI

APPLICATION advanced **ACTIVITY** T&E

ROLE
- predictions of human injury in automobile crashes

TYPE man-model, crash simulation

CLASS
- life support

STATUS operational

COST High

ADVANTAGES

- validated

DISADVANTAGES

- limited in use because of high specificity

SOURCE

CALSPAN Corporation

REFERENCES

Frisch, 1986
Hickey, et. al., 1985
Rothwell, 1987

COMMENTS

TOOL NAME: CINCI KID

Aviation Related? yes

Record # 54

DESCRIPTION

CINCI KID is a 3-D man-model with 15 body segments connected by ball and socket and hinged joints. It was developed in 1964 to predict human body inertial properties for any fixed body position. The man-model was positioned according to Euler angles. At the University of Cincinnati, it is used to predict the displacement and rotation of the main body when external forces (including G fields) and relative limb motions are defined.

REQUIREMENTS

INPUT REQUIREMENTS

- tool is obsolete

OUTPUTS

- tool is obsolete

RESOURCE REQUIREMENTS

- tool is obsolete

CLASSIFICATION

PHASE FSD, P&D, PI

APPLICATION advanced **ACTIVITY** T&E

ROLE
- predicts human body inertial properties

TYPE man-model

CLASS
- life support

STATUS operational

COST Moderate

ADVANTAGES

- no information available

DISADVANTAGES

- reach not addressed
- vision not addressed
- clearance not addressed

SOURCE

University of Cincinnati
Cincinnati, OH 45221

REFERENCES

Hickey, et. al., 1985
Rothwell, 1987

COMMENTS

TOOL NAME: COM-GEOM

Aviation Related? yes

Record # 55

DESCRIPTION

COM-GEOM is a man-modeling technique that has a 3-D man-model built from 23 geometric solids. This model is based on the anthropometric measures of 50-60th percentile personnel. A helmet may be included if desired. A variety of body positions may be simulated. Reach and clearance must be assessed visually. The program also includes body weight and density calculations for target and wound assessment.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• none identified	• none identified	• IBM mainframe and compatibles

CLASSIFICATION

PHASE: FSD

APPLICATION: advanced

ACTIVITY: design

ROLE:
- man-modeling

TYPE: man-model

CLASS:
- workstation design

STATUS: operational

COST: Low

ADVANTAGES

- uses 23 different body segments as opposed to the usual 15

DISADVANTAGES

- limited in addressing the physical compatibility problems of variable percentile personnel

SOURCE

Army Aeromed Research Lab
Ft. Rucker, AL 36362-5292

REFERENCES

Hickey, et. al., 1985
Rothwell, 1987

COMMENTS

TOOL NAME: CREW CHIEF

Aviation Related? yes

Record # 56

DESCRIPTION

CREW CHIEF was designed for use by aerospace manufacturers to improve maintainability and supportability. It is a CAD man-model that simulates an aircraft maintenance technician. The model, based on COMBIMAN, is constructed from a range of body sizes and proportions. Clothing, personal protective equipment and a wide variety of handtools may be incorporated into a study. Different postures and activities may be simulated. Visual and physical access to the target may be assessed. The program also includes the capability for assessing the technician's strength for each activity and handtool.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• anthropometry of user • posture of user	• analysis of physical access • analysis of visual access • LOS angles to controls and displays • LOS angles to objects outside crewstation (runways, other vehicles-planes, any desired object) • off-axis plots (not limited to forward looking) • different eye locations (not limited to design eye position) • peripheral vision limits • helmet and mask limits on visual field • cross reference to original drawings	• IBM 360/370 computer in FORTRAN

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** design

ROLE
- aircraft maintenance simulations

TYPE CAD, man-model

CLASS
- maintenance design
- reach
- vision
- workspace

STATUS operational

COST Moderate

ADVANTAGES

- flexibility to interface with various workplace databases and CAD systems
- includes various non-seated working postures
- considers strength of the technician (tools operation and materials handling)
- capability for variable body size and proportions
- incorporates encumberance of clothing
- simulates interaction with tools
- has fewer limitations than its predecessor COMBIMAN

DISADVANTAGES

- no information available

SOURCE

US Air Force Aerospace Medical Research Lab
Wright-Patterson AFB, OH 45433

REFERENCES

Hickey, et. al., 1985
Rothwell, 1987

COMMENTS

TOOL NAME: CYBERMAN

Aviation Related? no

Record # 57

DESCRIPTION

Cyberman was designed by Chrysler Corp. to simulate driver activity in and about a car. The model includes a 3-D, 15 link man-model which can represent any anthropometric percentile. This man-model may be just a stickman, or may have a wireframe outline of body contours. The eyepoint of the driver/passenger is indicated. The workplace model is called up from files contained in a separate system. The designer may manipulate the man-model's limbs and orient him within the workplace. Reach and clearance must be visually determined with the aid of the graphical output. The designer may obtain up to 36 different viewpoints of the man-workplace complex from various distances.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• user anthropometric percentiles • limb orientation • position of user (model) in or around car	• graphical determination of reach and distance	• IBM mainframe and compatibles

CLASSIFICATION

PHASE: D&V, FSD

APPLICATION: advanced

ACTIVITY: design

ROLE:
- man-models for automobile crash simulations

TYPE: man-model, crash simulation

CLASS:
- man-model
- reach
- vision
- workspace layout

STATUS: operational

COST: High

ADVANTAGES

- man and workspace models allow simulation of driver and passenger activities both in and around car
- includes both wireframe and stick-figure models

DISADVANTAGES

- no constraints on human movement
- does not account for clothing or restraint systems

SOURCE

Chrysler Corp.

REFERENCES

Hickey, et. al., 1985
Rothwell, 1987

COMMENTS

Unavailable commercially or by special permission

TOOL NAME: ERGOMAN

Aviation Related? yes

Record # 58

DESCRIPTION

ERGOMAN is a computer graphics system for simulating human figures and environments in 3-D. The human model is constructed of 18 segments and 20 articulations. More articulations may be specified for greater complexity. Three representations of the model are: the line model, the volume model, and the triangular model. The anthropometric dimensions of the model are taken fror. FRGODATA, which contains statistics on over 40,000 males and females of various ages. The designer positions one or more human models in the selected environment by manipulating the articulation points. All movements are constrained within angular joint limits.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• number of users • user size • workplace arrangement and workspace layouts	• visual determination of user reach and vision constraints	• UNIVAC 110 mainframe • EUCLID 3-D software (written in FORTRAN IV)

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** T&E

ROLE
- man-modeling in 3-D environments

TYPE man-model

CLASS
- reach
- vision

STATUS operational

COST High

ADVANTAGES

- specialized algorithms for CAD applications (multiple perspectives, cross-section representation, total or partial hidden line removal) are included in its structure

DISADVANTAGES

- does not allow for quantitative assessments of physical compatibility between the user and the workplace
- all analyses are performed visually by the designer
- no analytical routines for reach, vision
- insufficient documentation

SOURCE

Laboratory for Applied Anthropology and Human Ecology of France

REFERENCES

Hickey, et. al., 1985
Rothwell, 1987

COMMENTS

TOOL NAME: Graphical Marionette

Aviation Related? yes

Record # 59

DESCRIPTION

A man-modeling computer system with animated output. The computer is fed a "script-by-enactment". Light Emitting Diodes (LEDs) are placed on the joints and bony prominences of a human scriptor's body. A photo sensor tracks these LEDs to produce a set of positional data in real time. The Graphical Marionette models the primary segments and joints of the body. The first presentation of the figure to the user is a simple stick figure that may have minor enfleshment. After it has been approved, an enfleshed representation of the model is presented. The model's segment lengths and angular limits of motion are defined by database measures. Nonhuman jointed figures may be animated through Graphical Marionette also. The final version of this system will offer the definition of segment lengths directly from LED positional data, alteration of body types and exaggeration of features, multiple marionettes performing in sequence, and a script of an imaginary environment.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• contextual script	• positional x,y,z data for lower legs, thighs, hips, feet, shoulders, upper arms, lower arms, hands, trunk, neck, and head	• IBM mainframe and compatibles

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** design

ROLE
- man-modeling with animated output

TYPE man-model

CLASS
- workstation design

STATUS operational

COST High

ADVANTAGES

- allows real-time design and analysis

DISADVANTAGES

- does not include details of the hands and feet

SOURCE

MIT Architecture Machine Group
Cambridge, MA 02139

REFERENCES

Hickey, et. al., 1985
Rothwell, 1987

COMMENTS

TOOL NAME: HSRI Models

Aviation Related? yes

Record # 60

DESCRIPTION

Two 3-D biodynamic modeling programs were developed by the Highway Safety Research Institute of the University of Michigan. The first program was designed to predict occupant kinematics and occupant forces generated in vehicular impacts. In the simulation, the models wear lap belts and shoulder harnesses which can then be studied for the forces they place on the occupant. The original man-model and environmental model were updated to 6 body segments with 20 ellipsoids defining the outlines, and 30 permissible contact surfaces/planes around the occupant which represent the vehicle interior. The updated program incorporates joint constraint data and can simulate belt slippage.

REQUIREMENTS

INPUT REQUIREMENTS

- vehicle deceleration profiles
- initial position of the occupant
- inertial and kinematic properties of the occupant
- force-deflection characteristics of contact surfaces
- the belt restraint system

OUTPUTS

- tangential forces between body segments and contact surfaces
- intersegment (head and chest) forces

RESOURCE REQUIREMENTS

- mainframe (unknown)

CLASSIFICATION

PHASE: FSD

APPLICATION: advanced

ACTIVITY: design

ROLE:
- occupant forces in vehicular impacts

TYPE: man-model, crash simulation

CLASS:
- life support

STATUS: operational

COST: High

ADVANTAGES

- can simulate lap belt and shoulder harness slippage on vehicle occupants

DISADVANTAGES

- highly specific in application

SOURCE

Highway Safety Research Institute of the University of Michigan
Ann Arbor, MI 48109

REFERENCES

Hickey, et. al., 1985
Rothwell, 1987

COMMENTS

TOOL NAME: NUDES

Aviation Related? no

Record # 61

DESCRIPTION

NUDES is an animation program that constructs 3-D humanoid figures using about 20 ellipsoid enfleshed body segments. Vector and raster graphics displays present the figure in real-time. The outline of the figure is produced using a series of curved arcs on a vector display; on a raster display, color and shading define the figure.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• subject anthropometry	• 3-d figures	• mainframe (unknown)

CLASSIFICATION

PHASE D&V, FSD

APPLICATION advanced **ACTIVITY** design

ROLE
- physical education • dance • medicine • therapy • ergonomics

TYPE man-model, animated

CLASS
- workstation design

STATUS operational

COST Moderate

ADVANTAGES

- figures displayed in real-time

DISADVANTAGES

- lacks the basic requirements of a CAD tool for general workspace evaluations (analytical and workspace-modeling capabilities)

SOURCE

- University of Sidney
Sidney, Australia

REFERENCES

Hickey, et. al., 1985
Rothwell, 1987

COMMENTS

TOOL NAME: SIMULA/PROMETHEUS

Aviation Related? yes **Record #** 62

DESCRIPTION

SIMULA is a 2-D biodynamic computer program for simulating vehicle crashes. A man-model with 7 body segments represents the passenger. Interaction of the occupant with the vehicle interior occurs only with the seat and restraint systems. PROMETHEUS is a reversed version of SIMULA that incorporates an algorithm for the computation of segment-surface impact forces. The simulated vehicle surfaces can be made to yield plastically or collapse upon impact. A sagittally view occupant may be displayed as either a stickman or as a figure enfleshed by tangent lines which connect over 105 surface body points. Color and hidden line removal have been incorporated.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• none identified	• none identified	• mainframe (unknown)

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** T&E

ROLE
- simulates humns in vehicle crashes

TYPE man-model, crash simulation

CLASS
- life support

STATUS operational

COST High

ADVANTAGES

- seat belts and shoulder harness attachments may be displayed graphically
- applicable to aircraft landings and take-offs

DISADVANTAGES

- limited to analyses of planar motion because of 2-D modeling
- does not address reach
- does not address vision
- does not address clearance

SOURCE

Simula: Dynamic Science Inc.
Prometheus: Boeing Computer Services Inc.

REFERENCES

Hickey, et. al., 1985
Rothwell, 1987

COMMENTS

TOOL NAME: SFU Model

Aviation Related? no

Record # 63

DESCRIPTION

SFU Model is an animation program for kinematic simulations. A researcher may use this program for the visualization of dance script, called Labanotation, or for the clinical assessment of movement abnormalities. Over 50 movement gestures are written in Labanotation and stored in a library at SFU. Through an electrogoniometer, kinematic data may be directly input into the program for clinical assessment. Data for 16 of the 18 degrees of freedom of lower body joints may be input through electrogoniometer data. A program exists for the integration of arm movements from notation and walking movements defined by instrumentation. The man-model that is displayed on the graphics terminal is a 22 segment, 23 joint man-model. The graphical routine of either NUDES or BUBBLEMAN enflesh the figure with ellipses or spheres.

REQUIREMENTS

INPUT REQUIREMENTS

- labanotation: alphanumeric code
- clinical assessment: analog signals from an electrogoniometer

OUTPUTS

- movement sequences displayed on vector and raster graphics terminals

RESOURCE REQUIREMENTS

- Evans and Sutherland Picture System 1 with PDP 11/34
- PASCAL Microengine with Z80
- Apple II microcomputer

CLASSIFICATION

PHASE D&V, FSD

APPLICATION advanced **ACTIVITY** design

ROLE
- clinical assessment of movement abnormalities

TYPE man-model, animated

CLASS
- workstation design

STATUS operational

COST High

ADVANTAGES

- man-model may be either a stick-man or an enfleshed figure

DISADVANTAGES

- joints are not constrained by limits of motion
- joints are not constrained by obstructions in the environment

SOURCE

Simon Fraser University
Burnaby, British Columbia

REFERENCES

Hickey, et. al., 1985
Rothwell, 1987

COMMENTS

TOOL NAME: STICKMAN   Aviation Related? no   Record # 64

DESCRIPTION

STICKMAN was developed by IBM for predicting body segment masses and centers of mass using a series of regression equations. Anthropometric measures of the subject under study are collected, then a scaled stick-man model is generated from them and displayed on the CRT. Depending on the anthropometric data available, the designer then applies the appropriate regression equations. The center of mass of the main body segment may be computed from the centers of mass of its component parts. These centers of mass are light penned on the graphical display so that they may be included in the computation. A total of 23 segment mass and center of mass computations may be calculated.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• eleven anthropometric reference measures of the subject under study • batch card input with interactive alterations using lightpen or keyboard commands	• CRT displays • hard copy print-outs • center of mass results in correct position on the man-model	• written in assembler and FORTRAN IV • IBM System/360, Model 40 computer

CLASSIFICATION

PHASE: D&V, FSD

APPLICATION: advanced

ACTIVITY: design

ROLE:
- predicting body segment masses and centers of gravity

TYPE: man-model

CLASS:
- workstation design

STATUS: operational

COST: High

ADVANTAGES

- batch card input can be supplemented with lightpen or keyboard commands to allow for interactive alterations

DISADVANTAGES

- does not simulate environment
- no analytical capabilities for reach
- no analytical capabilities for vision
- no analytical capabilities for clearance
- no analytical capabilities for ingress or egress

SOURCE

Developed by IBM for:
US Air Force Aerospace Research Lab
Aerospace Medical Division
Air Force Systems Command
Wright-Patterson AFB, OH 45433

REFERENCES

Hickey, et. al., 1985
Rothwell, 1987

COMMENTS

NAME: TTI Models

Aviation Related? no

Record # 65

DESCRIPTION

TTI is a biodynamic modeling computer program used to simulate vehicular impacts. The program incorporates a 3-D occupant model made of 12 body segments, represented by ellipsoids and connected by ball-and-socket joints. The interior of the vehicle is represented by a maximum of 20 planar contact surfaces. A revision added auto-pedestrian impacts.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• none identified	• none identified	• mainframe (unknown)

CLASSIFICATION

PHASE D&V, FSD

APPLICATION advanced **ACTIVITY** design

ROLE
- automobile crashes

TYPE man-model, crash simulation

CLASS
- man-model
- crash simulation

STATUS operational

COST Moderate

ADVANTAGES

- joint constraints are included
- spinal elasticity is included
- restraints systems (lap belt and shoulder belt combinations) are included

DISADVANTAGES

- does not account for intersegment contact
- does not address reach
- does not address vision
- does not address clearance
- does not address ingress or egress
- results of a validation study were poor

SOURCE

Texas Transportation Institute

REFERENCES

Hickey, et. al., 1985
Rothwell, 1987

COMMENTS

In 1974 the TTI model was revised to include automobile pedestrian impacts. Ellipsoids replace spheres in representing the body segments and joint constraints were simulated by a different technique. Validation results were considered good.

TOOL NAME: UCIN

Aviation Related? yes

Record # 66

DESCRIPTION

UCIN is a 3-D biodynamic program for simulating vehicle collisions and high acceleration. A 12 segment man-model is used for studying frontal collisions. The segments are formed from elliptical cylinders, ellipsoids, and frustrums of elliptical cones. UCIN-NECK is a model developed to be incorporated in UCIN for simulating the motion of the head and vertebrae in the neck during impacts and high accelerations.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• no information available	• interaction of body segments and contact forces	• output is on both vector and color raster terminals

CLASSIFICATION

PHASE	D&V, FSD	CLASS	• life support
APPLICATION	advanced	ACTIVITY	design, T&E
ROLE	• simulations of vehicle collisions	STATUS	operational
TYPE	man-model, crash simulation	COST	High

ADVANTAGES

- constraints on joints within angular limits
- applicable to aircraft landings and take-offs

DISADVANTAGES

- program lacks the generality required to address anthropometric issues and various working environments
- contact forces are not generated

SOURCE

University of Cincinnati
Cincinnati, OH 45221

REFERENCES

Hickey, et. al., 1985
Rothwell, 1987

COMMENTS

TOOL NAME: GENSAW (Generic Systems Analyst Workstation) **Aviation Related?** yes **Record #** 67

DESCRIPTION

GENSAW is a system analyst/designer workstation consisting of a large set of analytical capabilities available on a user-assisted, interactive, and optional basis. Some of its capabilities include: mission/scenario decomposition, function and/or task analysis, resource allocation, system decomposition in terms of IDEF diagrams including system mods, updates, etc., information flow analysis, network model development, simulation model development. GENSAW stores IDEF (ICAM [Integrated Computer Aided Manufacturing] Definition) diagram information created by the user(s) allowing "spin-off" of analysis capabilities. The component parts of GENSAW are:
1)AED-user-assisted experimental design program-a computer terminal interface for generating system test designs; planning for system testing and data collection
2)TEMAP-user-assisted test and evaluation methodology assistant program (TEMAP)-a computer terminal interface; guidelines for planning and performing system T&E; T&E program stages
3)ASD-user-assisted system decomposition program-a computer terminal interface; functional decomposition via IDEF diagramming technique; analysis capability (e.g., resource allocation)
4)GENSAW-user-assisted generic systems analyst workstation-computer terminal interface; IDEF+analysis=ASD; ASD+ additional analysis (e.g., model/simulation, AED, TEMAP)=GENSAW
TEMAP is an interactive analysis tool developed for GENSAW. TEMAP allows the analyst to overview an IDEF structured T&E program, structure a T&E problem in a disciplined manner, select a specific stage in the T&E IDEF structure to examine, review decision listings, factors to consider, applicable references and other pertinent material, cross-reference critical methodological issues with potential solutions (e.g., methods, techniques, procedures, guidelines, etc.)

REQUIREMENTS

INPUT REQUIREMENTS
- user created IDEF diagram-decomposition of system
- network model-links between inputs and outputs in the IDEF

OUTPUTS
- physical layouts
- task sets
- function sets
- task networks
- event analyses
- resource allocation
- task networks critical paths and bottlenecks
- system models
- cost analyses
- system prototypes
- safety considerations
- workload estimates
- cost estimates

RESOURCE REQUIREMENTS
- VAX 11/780 with 19" display terminal and keyboard
- operating system is VMS
- written in FORTRAN 77
- interfaces can be written in PASCAL
- microVAX II workstation
- GKS (graphics interface system for VAX)

CLASSIFICATION

PHASE: CE, D&V, FSD

APPLICATION: advanced

ACTIVITY: analysis

ROLE: • SAC LCC • B-1B BOMBER • NORAD COMMAND POST • SOPC • ADIC • CHEMICAL DEFENSE • PILOT'S ASSOCIATE PROGRAM

TYPE: family of tools

CLASS:
- FEA
- task analysis

STATUS: operational

COST: High

ADVANTAGES

- FCNS verified by tactical pilots
- will send specialist out to help set up the program
- menu-driven interface
- built-in help feature

DISADVANTAGES

- interface is not user-friendly
- current program does not support access to human performance data base

SOURCE

Dr. Bob Mills
AAMRL/HEF
Wright-Patterson AFB
OH 45433-6573

REFERENCES

Mills, 1986

COMMENTS

Work in progress to access GENSAW via PC, improve user-friendliness, add MicroSAINT simulation capability, and add human performance, reference and hardware databases

TOOL NAME: CRAWL

Aviation Related? yes

Record # 68

DESCRIPTION

CRAWL was developed to estimate the workload for a task along a continuum. The task is broken down into sections or channels and an estimate of the workload for that channel is input. CRAWL establishes a timeline of events for completing the task along with the corresponding workload associated at each channel along the timeline.

REQUIREMENTS

INPUT REQUIREMENTS

- timeline for the task
- estimate of the amount of workload per channel

OUTPUTS

- workload timeline

RESOURCE REQUIREMENTS

- IBM PC and compatibles

CLASSIFICATION

PHASE Pre-Con, CE, D&V, FSD

APPLICATION advanced **ACTIVITY** analysis

ROLE
- Air Force 1
- LHX helicopter

TYPE task model, workload; task model, timeline

CLASS
- workload analysis
- T&E
- FEA

STATUS operational

COST Low

ADVANTAGES

- validated

DISADVANTAGES

- no information available due to program's proprietary nature.

SOURCE

Dr. R.P. Bateman
Boeing Military Airplane Co.
Mail Stop K76-23
Wichita, KN 67277-7730

REFERENCES

Bateman, R.P. (1987)

COMMENTS

CRAWL is proprietary

TOOL NAME: HIMS (Helicopter Inflight Monitoring System) II

Aviation Related? yes

Record # 69

DESCRIPTION

HIMS is a self-contained apparatus for monitoring a pilot's actions as he flies an aircraft. HIMS II contains 64 channels of information, coming from transducers that take readings of instruments and the "stick" at regular intervals. With this data, scenarios can be reconstructed to analyze pilot performance under differing conditions. For example, a comparison study was done on the effect of night vision goggles on pilot performance. Pilots flew with the HIMS II in their aircraft without the goggles to obtain a baseline reading, then with the goggles on to compare the effects. HIMS II is transportable between aircraft.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• baseline trial for comparison • trial run using dependent variable	• instrument and stick readings at regular intervals	• self-contained computing system

CLASSIFICATION

PHASE D&V, FSD, P&D, PI

APPLICATION advanced **ACTIVITY** analysis

ROLE
- helicopter accident evaluation

TYPE task model, performance

CLASS
- performance analysis

STATUS operational

COST High

ADVANTAGES

- light weight transducers
- small transducers

DISADVANTAGES

- proprietary

SOURCE

Lewis Stone
Army Aeromed Research Lab
Ft. Rucker, AL 36362-5292

REFERENCES

Stone,1986

COMMENTS

HIMS II is a proprietary system

TOOL NAME: ZITA (Zero Input Tracking Analyzer) | Aviation Related? yes | Record # 70

DESCRIPTION

ZITA is used to develop a method of predicting shifts in behavior as a result of workload-induced stress. ZITA is designed to test a person's tracking ability. The object in using ZITA is to track a cursor on a 17 X 192 dot matrix display. Using a joystick, the person tries to keep the cursor in a triangle located at the center of the bottom of the screen. The joystick responds through internal device instructions for acceleration, velocity, jerk, and fixed input. ZITA is excellent for testing the stress factors which contribute to a person's tracking skill. For example, it has been used in testing secondary task interference with the primary task.

REQUIREMENTS

INPUT REQUIREMENTS

- joystick movement

OUTPUTS

- dot matrix screen display--interactive program
- can be linked to an RS232 connector for computer readouts and statistical analysis
- accumulates data from up to 40 trials and give the results from each of those trials--can run one person through 40 different trials, or 40 different people through a single trial

RESOURCE REQUIREMENTS

- self-contained
- hardwired for linkage to any RS232 connector
- programmed on Apple II for runs

CLASSIFICATION

PHASE CE, D&V, FSD

APPLICATION advanced **ACTIVITY** Analysis

ROLE
- workload and stress as it affects tracking skills

TYPE task model, timeline; task model, performance

CLASS
- performance analysis
- workload analysis

STATUS operational

COST Low

ADVANTAGES

- portable
- self-contained

DISADVANTAGES

- unvalidated
- reset button terminates the program instead of putting the operator at the beginning of the program, and all data is lost

SOURCE

Norman Walker Associates
Maryland

REFERENCES

Stone, 1986

COMMENTS

TOOL NAME: SPRINGMAN

Aviation Related? yes

Record # 71

DESCRIPTION

SPRINGMAN is a man-model program based on the Apollo Graftek graphics package. It allows the designer to input any percentile range and test for fit, reach , function, vision, obstruction. The model may be placed in any position for the testing. The environment is modeled for simulating man-machine interaction. The designer can input as few points of reference as he needs to complete the particular assessment. All body parts are moveable in action sequences.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• select population parameters • environment parameters • isolate the points to be studied	• reach assessment • fit assessment • cockpit visibility • function assessment	• Gerber Scientific Corp. • Apollo - CAD/CAM - Graftek system HP 2308 mini

CLASSIFICATION

PHASE: FSD

APPLICATION: advanced **ACTIVITY:** design

ROLE:
- LHX-visibility tests
- Air Force 1-navigator's position

TYPE: graphics man-model

CLASS:
- workstation design
- reach/vision analysis

STATUS: operational

COST: High

ADVANTAGES

- good range of anthropometry (5th-95th percentile, male/female)
- little training required
- uses NASA anthropometric data

DISADVANTAGES

- moves slowly because the elipses and splines are defined with outdated methods
- not validated

SOURCE

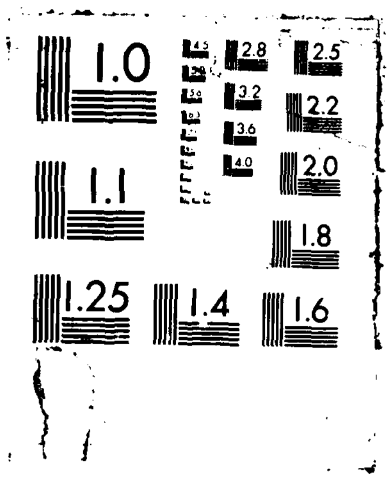
[illegible] Airplane Co. [illegible]

REFERENCES

Bateman, 1987
Thompson, 1987

AD-A189 390 ADVANCED HUMAN FACTORS ENGINEERING TOOL TECHNOLOGIES 3/3
(U) CARLOW ASSOCIATES INC FAIRFAX VA S A FLEGER ET AL.
20 MAR 87 DAAA15-86-C-0064

UNCLASSIFIED F/G 23/2 NL


1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

TOOL NAME: SLAM II (Simulation Language for Alternative Modeling) | Aviation Related? yes | Record # 72

DESCRIPTION

SLAM II is a language that allows simulations to be built based on three different world views. It provides network symbols for building graphical models that are easily translated into input statements for direct computer processing. It contains subprograms that support both discrete event and continuous model developments, and specifies the organizational structure for building such models. By combining network, discrete event, and continuous modeling capabilities, SLAM allows the systems analyst to develop models from a process-interaction, next-event, or activity-scanning perspective. The interfaces between the modeling approaches are explicitly defined to allow new conceptual views of systems to be explored.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• flowchart that breaks down the steps of the activity being simulated • write program using subroutines	• summary report presenting statistics on time related factors of the simulation, and the effect of dependent variables on the overall efficiency of the system	• FORTRAN • IBM • IBM PC • VAX 11/780

CLASSIFICATION

PHASE Pre-con, CE, D&V

APPLICATION advanced **ACTIVITY** analysis, T&E

ROLE
- flow diagramming for pilot ejection procedure

TYPE task model

CLASS
- FEA
- performance analysis
- task modeling

STATUS operational

COST High

ADVANTAGES

- detailed modeling
- probabilistic, stochastic
- random number generation
- graphics available

DISADVANTAGES

- requires a lot of front-end work
- have to have good working knowledge of FORTRAN
- have to know how to interpret results

SOURCE

Pritsker & Associates, INC.
P.O. Box 2413
West Lafayette, IN 47906

REFERENCES

Rose, 1987 (d)
Smootz, 1987

COMMENTS

TOOL NAME: ETAS (Essex Training Analysis System)

Aviation Related? yes **Record #** 73

DESCRIPTION

ETAS was designed to use a structured numbering system which allows all job and task analysis data to be linked to specific learning objectives, lesson plans, and test items.

There are 6 major modules in ETAS:

1) job analysis module
2) task analysis module
3) job performance measure module
4) learning objective module
5) test item data module
6) code table module

REQUIREMENTS

INPUT REQUIREMENTS

Job analysis
- job survey info from individuals in the field

Task analysis
- conditions, initiating cues, element number, element criticality, element conditions, element references, element standards, element tools /equipment, element skills and knowledge, terminating cues, outputs, standards, results of poor performance, personnel safety considerations

Job performance measure
- conditions, references, tools/equipment, standards, trainee checklist, scoreable characteristics, performance standards, directions to the instructor, recommended training setting, mode and media

Learning objective
- all task data/learning objective data

Test item data
- true/false, multiple choice, matching, fill in the blank, and short essay questions

Code table data
- skill/knowledge statements
- code numbers for references, standards, tools

OUTPUTS

Job analysis
- response data according to distribution of frequency, importance, and difficulty variables
- mean average and std. dev. for each response category
- relative training priority for each task

Task analysis
- complete task record
- list of tasks which refer to the same references, tools/equipment, taxonomy codes or standards

Job performance measure
- task data redefined as a job performance measure

Learning objective
- task data redefined as learning objectives
- task data linked to learning objective and task
- data in sequence for each training program
- learning objectives at the lesson plan level
- method used to teach the learning method

Test item data
- random selection generation of test item
- <=100 questions per test
- questions by difficulty level

Code table module
- skill/knowledge statements assigned to tasks by code number

RESOURCE REQUIREMENTS

- IBM or IBM compatible PC
- 384K memory
- hard disk

CLASSIFICATION

PHASE CE, D&V, FSD

APPLICATION advanced **ACTIVITY** analysis

ROLE
- training effectiveness
- job analysis

TYPE database

CLASS
- training analysis

STATUS operational

COST Moderate

ADVANTAGES

- minor modifications to program are free of charge
- training session included with purchase

DISADVANTAGES

- test item data module limited to 100 questions

SOURCE

Essex Corporation
333 N. Fairfax St
Alexandria, VA 22314
(703) 548-4500

REFERENCES

Cochran, 1986 (a)
Cochran, 1986 (b)

COMMENTS

TOOL NAME: ICAM (Interactive Control Assessment Methodology) | Aviation Related? no | Record # 74

DESCRIPTION

ICAM will be used to compare approaches to automation problems. It compares 2 information intensive interfaces (e.g., spread sheets) to see which will be more productive for an operator to use. It considers time to perform, and the quality of work that an operator can produce in that time, and makes tradeoffs.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• description of the systems' capabilities	• time to perform the tasks • operational curve that maps output quality versus time spent in production	• VAX • VMS operating system

CLASSIFICATION

PHASE Pre-con, CE, D&V, FSD

APPLICATION advanced **ACTIVITY** analysis

ROLE
- compares approaches to automation problems

TYPE task model, workload; task model, timeline

CLASS
- workload analysis
- T&E
- FEA

STATUS conceptual

COST High

ADVANTAGES

- NA, conceptual module

DISADVANTAGES

- NA, conceptual module

SOURCE

Essex Corporation
333 N. Fairfax St
Alexandria, VA 22314
(703) 548-4500

REFERENCES

Reiner, R., 1987

COMMENTS

TOOL NAME: BEMOD (Behavior Modification) **Aviation Related? no** **Record # 75**

DESCRIPTION

BEMOD consists of several submodels including a visual detection of targets system, fatigue levels of operators, communications probability of contact, task layouts, and decision making. BEMOD contains algorithms of simulations of various aspects of human performance, and its underlying processes. Simulated humans in the program have these duties to perform: acquire information, retain information, transmit information, process information, move about and perform tasks. These activities take place within the physical limitations imposed by the geometric layout of the simulated ship's space, the illumination and background noise present, and the temperature and humidity of the simulated environment.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• target luminance • target clothing • skill level of person being modeled • training level of person being modeled	• probability of detecting the target at a specific distance under specific conditions • summary statistics, fatigue levels, communications probabilities	• written in FORTRAN • VAX 11/780 • VMS operating system • adaptable to UNIX with minor modifications

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** analysis

ROLE
- security system design programs
- security personnel training programs

TYPE task model

CLASS
- task modeling
- visual analysis
- workload analysis
- performance analysis

STATUS prototype

COST Moderate

ADVANTAGES

- no information available

DISADVANTAGES

- no information available

SOURCE

US Navy Personnel Research and Development Center
San Diego, CA 93102

REFERENCES

Stinson, 1987
Ewing, & Caccamise, 1983

COMMENTS

Final funding for the project debugging and documentation was delayed; it is expected to be completed by the end of FY 87.

TOOL NAME: CVAS (Crewstation Vision Analysis System) **Aviation Related?** yes **Record #** 76

DESCRIPTION

CVAS allows researchers to simulate the view of a pilot in a cockpit. CVAS scans through graphics and the windows in the cockpit and presents obstructions both inside and outside the hatch. It checks instrument readability. It also checks for clear visibility when approaching a runway or carrier deck. It was originally designed to simulate the cockpit of a 757, and 767 in the prototype testing stage.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• cockpit geometry • runway dimensions • aircraft geometry	• view from the pilot's eye • obstructions, both internally and externally, of the pilot's view	• Cyber • Cray

CLASSIFICATION

PHASE D&V, FSD

APPLICATION advanced **ACTIVITY** design, analysis

ROLE
- cockpit layout for the Boeing 757 and 767

TYPE man-model, simulation

CLASS
- crew station design

STATUS operational

COST High

ADVANTAGES

- incorporates window refraction

DISADVANTAGES

- no information available

SOURCE

Boeing commercial Airplane
Box 3707
MS 77-70
Seattle, WA 98072

REFERENCES

Jones, R., 1982

COMMENTS

Proprietary

TOOL NAME: CAPRA (Computer Aided Probabilistic Risk Assessment) **Aviation Related? yes** **Record # 77**

DESCRIPTION

CAPRA is a hardware reliability model. It integrates hardware status with machine operation If there are two problems with a system, CAPRA will direct the operator to the most important problem first, step him through the correction, then put up a hardware flag that warns of the second failure. The system is based on micro motions, or steps required to perform a task. Once a task has been broken into micro motions, these micro motions are categorized by difficulty level. The difficulty is considered in the prediction of the time spent in performing the task, and the workload necessary to perform each portion of the task.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• build a database of micro motions • incorporate micro motions in a flow chart • break down the flow chart into tasks • build a work sequence chart for each task	• time on each task • probability of failing the task • detailed breakdown of time spent in performing each part of the task	• IBM PC and compatibles

CLASSIFICATION

PHASE: FSD

APPLICATION: advanced

ACTIVITY: design, T&E

ROLE:
- copiers

TYPE: reliability model

CLASS:
- maintenance analysis

STATUS: operational

COST: Moderate

ADVANTAGES

- integrates dynamic hardware status with machine operation

DISADVANTAGES

- documentation incomplete
- not validated
- no interactive interface-have to create input decks separately

SOURCE

Essex Corporation
333 N. Fairfax St
Alexandria, VA 22314
(703) 548-4500

REFERENCES

Reiner, R., 1987

COMMENTS

TOOL NAME: TEMPUS

Aviation Related? yes

Record # 78

DESCRIPTION

TEMPUS incorporates a workstation generation module and an anthropometric man-model. The user can define the workstation using PLAID graphics. The man-model is created using the TEMPUS graphics package. A woman can be modeled if desired. Objects can be scaled, viewing angles can be changed, and lighting can be varied within the workstation. The display can be presented with wireframe graphics or with geometric solids. The user has the choice of a mouse, a keyboard, or a digitizing tablet for data entry. Man-model anthropometrics for TEMPUS are based on the validated CAR data. The man-model includes joint limitations. Future improvements include multiple restraints for body positioning, strength analysis, more detailed vision analysis.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• can input own anthropometric data or use the existing database	• interactive graphics on the screen • no reports to speak of because it is not a statistical analysis technique	• DEC-VAX 11/780 • Tektronix 4115

CLASSIFICATION

PHASE D&V, FSD

APPLICATION advanced **ACTIVITY** design

ROLE
- crew compartments for various space shuttles

TYPE man-model, workspace model

CLASS
- workstation design

STATUS operational

COST High

ADVANTAGES

- developers are willing to custom tailor the system to meet customer's needs
- offers three hand reach types
- includes comfort joint limitations
- includes visibility diagrams
- includes help feature
- represents humans and workspace in 3-D
- interactive color graphics
- addresses single and multiple reaches
- allows visual determination of body clearance problems
- workstation module not limited to cockpit design

DISADVANTAGES

- no control for somatotypes in the man-model
- no dynamic control (forces)
- regression equation inappropriate for modeling females
- does not consider the effects of clothing on body position and joint limitations
- can only be used with single seated operator workplaces

SOURCE

University of Pennsylvania
Dr. Baddler
(215) 898-5862

REFERENCES

Baddler, 1987

COMMENTS

Proprietary-customers may request work to be done on TEMPUS, but may not purchase the tool itself.

TOOL NAME: CUBITS (Criticality/Utilization/Bits of Information) | Aviation Related? yes | Record # 79

DESCRIPTION

CUBITS is a set of computations for determining the amount of space which should be allocated to a control or display. These computations may be done by hand or on a computer. CUBITS computes the size of the display based on how important it is (criticality), how often it is used (utilization), and how much information an operator gets from the display or transfers to the control (bits of information). From a set of CUBITS computations or a CUBITS simulation, the designer can determine how big to make a control or display.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• estimate of control/display importance • estimate of control/display frequency of use • estimate of information transfer	• preferred control/display size • estimate of panel size required for control/display allocation	• CDC 6600

CLASSIFICATION

PHASE FSD

APPLICATION advanced **ACTIVITY** design

ROLE
- allocation of control and display space

TYPE workspace model

CLASS
- CD design
- panel design

STATUS operational

COST Moderate

ADVANTAGES

- computations can be performed manually, which may save time if small panels are involved

DISADVANTAGES

- does not address task or system performance
- does not address vision
- does not address reach
- does not address escape
- does not address percentage of operator population accommodated or excluded by crewstation dimensions
- does not address crewstation compliance with specific military standards
- does not have a graphics display
- does not have interactive design layout capability
- does not print graphic illustrations

SOURCE

Man-Machine Integration Division
Naval Air Development Center
Warminster, PA 18974

REFERENCES

DoD-HDBK-XXX, 1986

COMMENTS

TOOL NAME: Designer's Associate | Aviation Related? | Record # 80

DESCRIPTION

The Designer's Associate is a computerized knowledge-based data management system which will aid system designers in locating and interpreting technical data pertinent to their needs. Subject matter experts were consulted. The Designer's Associate presents human sensory/perceptual and performance data in a form useful to system designers, particularly aircrew station designers. Topics include: sensory acquisition of information (vision, audition, vestibular senses, cutaneous senses, and kinesthesia), perception of motion, posture, and spatial orientation, perceptual organization and spatial awareness, human language processing, information storage and retrieval, attention and allocation of resources, human operator control, target acquisition, human anthropometry, decision making and problem solving, learning and memory. The database provides comprehensive information on the capabilities and limitations of the human operator, with special emphasis on those variables which affect the operator's ability to acquire, process, and make use of task critical information. The database consists of concise two-page data entries on basic human performance data, section introductions outlining the scope of a group of entries and defining special terms, summary tables integrating data from related studies, descriptions of human perceptual phenomena, models and quantitative laws, principles and nonquantitative laws (nonprecise formulations expressing characteristics of perception and performance), tutorials on specific topics to help the user understand and evaluate the material in the database. Information is presented graphically whenever possible, in the form of figures or tables. The goal is to provide information in discrete units that are easily understood by a user with little expertise in the topic area.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• keywords for a search	• information pertaining to a specific topic	• undecided at this time

CLASSIFICATION

PHASE CE, D&V, FSD

APPLICATION advanced **ACTIVITY** design, T&E

ROLE
- design of aircrew stations

TYPE expert system

CLASS
- performance

STATUS conceptual

COST Moderate

ADVANTAGES

- NA, conceptual tool

DISADVANTAGES

- NA, conceptual tool

SOURCE

Developed by MacAulay-Brown, the University of Dayton Research Institute, and Essex Corporation for the Armed Services and NASA

Dr. Kenneth Boff
AAMRL/HEA
Wright-Patterson AFB, OH 45433

REFERENCES

Gordon, 1986
Gordon, 1987

COMMENTS

Database for expert system will be based in part on Boff and Linclon's Engineering Data Compendium: Human Performance and Perception (tentatively planned for publication during FY '87), and Boff, Kaufmann, and Thomas (1986): Handbook of Perception and Human Performance, Vols. 1 and 2.

TOOL NAME: POSIT **Aviation Related?** no **Record #** 81

DESCRIPTION

POSIT is a method of animating figures. Figure positions may be designed interactively by using a six-axis input device to establish joint angles and locate multiple constraints between joints and goal positions. POSIT uses a real-time display to aid visualization. The user inputs information with a 6-axis digitizer (Polhemus). The program incorporates a constraint satisfaction algorithm to improve the user's ability to achieve the desired algorithm. The 6-axis digitizer supplies the program with the 3-D *position in space* (x,y,z), and the *orientation* (yaw, pitch, roll) of the user's hand using a wand. The Polhemus provides the user with 3 degrees of *freedom*. With it, the user can orient each joint of the articulated figure. 4 different views of the body are provided, which facilitate placing the joints.

The body is represented as a hierarchical tree. The lower torso is the root of the tree, and each node has segments connected to it. The body hierarchy is defined by an ASCII input file which is modifiable by the user.

REQUIREMENTS

INPUT REQUIREMENTS

- selection of body segments
- selection of segments angles
- identification of segment goals

OUTPUTS

- position of body segment in 3-D space

RESOURCE REQUIREMENTS

- Silicon Graphics Iris Workstation; program written in C

CLASSIFICATION

PHASE FSD, D&V

APPLICATION advanced **ACTIVITY** design

ROLE
- animated figures

TYPE man-model animation

CLASS
- reach analysis

STATUS operational

COST High

ADVANTAGES

- menu driven system with all commands displayed on the screen at once
- real-time display, six-axis input device and multiple constraint positioning assistance makes for an easier and more natural method of positioning articulated figures in a 3-D scene
- can accommodate animals and inanimate objects

DISADVANTAGES

- none identified

SOURCE

Kamran H. Manoochehri
MS-CIS-86-96
University of Pennsylvania
Philadelphia, PA 19104

REFERENCES

Manoochehri, 1985

COMMENTS

TOOL NAME: Knowledge-based HFE Document Preparation System — Aviation Related? no — Record # 82

DESCRIPTION

This knowledge-based system is designed to aid in the construction of HFE contractual requirements, and for the management of HFE input throughout the life cycle of material development and acquisition. An objective of the system is to insure that MANPRINT issues are properly addressed in Army contracts. With this system, organizational HFE expertise is made explicit and encoded in a form that makes it easily available. The approach taken integrates 3 computer programs. The first is called COPE (Contract Preparation Environment). It contains knowledge of contract preparation regulations and standards. The second program is called POSE (Program Organization and Scheduling Environment). POSE captures knowledge of the sequence of activities involved in HFE management. The final program is called HEED (Human Engineering Equipment Design). This is an intelligent user interface which is a repository for the domain (human factors and Army equipment design) specific knowledge

REQUIREMENTS

INPUT REQUIREMENTS

- complete description of the system

OUTPUTS

HEED

- using imbedded HFE expertise, it infers those particular areas, stations, or substations which require concentrated HFE attention, due to the sensitivity or criticality of the operation

COPR

- a selection and arrangement of the sections of text to be used as the document's building blocks

POSE

- the past and present HFE contracts, program plans, review results, design recommendations, progress reports, deviation reports. standards, regulations, handbooks, data and other documentation necessary to justify HFE actions
- organizes these documents by specifying how they fit into the overall plan

GENERAL

- a tailored MIL-H-46855 and a tailored SOW

RESOURCE REQUIREMENTS

- Apple Macintosh
- adaptable to MS DOS compatible computers

CLASSIFICATION

PHASE Pre-con, CE, D&V, FSD, P&D, PI

APPLICATION advanced **ACTIVITY** design, analysis, T&E

ROLE
- document preparation

TYPE Data Access, expert system

CLASS
- FEA
- management
- T&E

STATUS prototype (limited)

COST Moderate

ADVANTAGES

- . reference window which provides advice, citations, references, policies, proc dures, comments, and alternative considerations.

DISADVANTAGES

- none identified; system currently in feasibility testing stage

S URCE

Richard S. Camden
US Army HEL
CSSD
ATTN SLCHE-CS (CAMDEN
APG, MD 21005-5001

REFERENCES

Camden, 1986

COMMENTS

FY '87 plans are to complete the feasibi v demonstratio and transition to a working prototype suitable for field evaluation

TOOL NAME: SIMKIT

Aviation Related? yes Record # 83

DESCRIPTION

SIMKIT is built on the Intellicorp expert system shell, KEE (Knowledge Engineering Enviro... t). SIMKIT builds simulations and attaches iconic displays to them. Through these icons, control of the simulation is obtained. Changing an icon can change the s... lation. If you change the parameters, SIMKIT will produce statistics on performance and user interaction.

REQUIREMENTS

INPUT REQUIREMENTS

- icons-either drawn with the help of the icon editor, or taken from the stock

OUTPUTS

- effects of change to the simulation in terms of performance statistics and user interactions

RESOURCE REQUIREMENTS

- Symbol... s LISP machine
- in the pro... ss of being converted to C for use on UNIX

CLASSIFICATION

PHASE: Pre-con, CE

APPLICATION: advanced

ACTIVITY: analysis

ROLE:
- simulations
- performance evaluations

TYPE: expert system

CLASS:
- simulation

STATUS: operational

COST: High

ADVANTAGES

- the only requirement for changing the simulation is to change the icons

DISADVANTAGES

- none identified

SOURCE

Intellicorp
Also owns KEE, the expert system shell on which SIMKIT is built

REFERENCES

Hester, 1987

COMMENTS

TOOL NAME: DART (Data Analysis and Retrieval Technique) | Aviation Related? yes | Record # 84

DESCRIPTION

DART takes a scenario, breaks it down into component tasks and analyzes the workload associated with the tasks. It breaks the elements of the tasks into elemental motions and presents an analysis of the motions based on which hand performs each action. A total time to complete each task is presented as well as a total time to complete the entire scenario.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• description of the task at goal level (step-by-step breakdown) • description of the workplace • 2-D breakdown of the environment	• right hand/left hand analysis of motions performed • how long each task takes • total time to complete the sequence	• IBM mainframe • IBM PC • Apple II and compatibles

CLASSIFICATION

PHASE Pre-Con, CE, D&V, FSD

APPLICATION advanced **ACTIVITY** analysis

ROLE
- manufacturing and assembly of commercial and military aircraft

TYPE task model, workload, task model, timeline

CLASS
- workload analysis
- T&E
- FEA

STATUS operational

COST Moderate

ADVANTAGES

- DART has been running successfully for over 7 years
- DART has been validated extensively with motion analyses

DISADVANTAGES

- no information available

SOURCE

Douglass Towne
P.O. Box 7090-421
Redondo Beach, CA 90277

REFERENCES

Towne, 1987

COMMENTS

TOOL NAME: PROFILE | Aviation Related? yes | Record # 85

DESCRIPTION

PROFILE is a generic expert troubleshooting shell. It uses a model of someone doing troubleshooting on a specific system to enable the designer, while still in the design phase, to determine if the system will be effectively repairable. PROFILE can estimate the mean time to repair a system; thereby, presenting downtime information.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• model of someone doing troubleshooting • block diagram of the functional layout of the system	• repair time/down time • an estimate of the repairability of a system while that system is still in the design phase of development	• Sun • Apollo • IBM-AT (in the process of being converted)

CLASSIFICATION

PHASE D&V

APPLICATION advanced **ACTIVITY** design

ROLE
- aircraft repair time

TYPE expert system

CLASS
- maintenance analysis

STATUS operational

COST High

ADVANTAGES

- generic troubleshooting program is generalizable to maintenance issues associated with any system

DISADVANTAGES

- graphical input routines are cumbersome

SOURCE

Douglass Towne
P.O. Box 7000-421
Redondo Beach, CA 90277

REFERENCES

Towne, 1987

COMMENTS

TOOL NAME: MOPSIE (Multiple Operator Parallel Systems Evaluation)

Aviation Related? no **Record #** 86

DESCRIPTION

MOPSIE is a predictor of productivity in concurrent systems with multiple operators. It was designed specifically for studying copiers for Xerox Corporation. MOPSIE is a comparative model that incorporates the training and intelligence levels of the operators. If the operator can preplan his workload, he can get more effective use out of the machine. MOPSIE incorporates sequencing rules which define how the machine is to be used (e.g., whether or not one paper tray can be filled while the machine is running using another paper tray).

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• workload specification • operator skill level- how far ahead he can plan • system configuration • sequencing rules	• best case productivity level • medium case productivity level • worst case productivity level	• VAX • VMS operating system

CLASSIFICATION

PHASE D&V, FSD

APPLICATION advanced **ACTIVITY** analysis

ROLE
- copier productivity

TYPE information model

CLASS
- workload analysis
- evaluation

STATUS operational

COST High

ADVANTAGES
- comparative model

DISADVANTAGES
- restricted environment

SOURCE
Essex Corporation
333 N. Fairfax St
Alexandria, VA 22314
(703) 548-4500

REFERENCES
Reiner, 1987

COMMENTS

TOOL NAME: Function Allocation Decision Aid **Aviation Related?** yes **Record #** 87

DESCRIPTION

The Function Allocation Decision Aid is an expert system used to evaluate function allocations between crew members and automation. Based on trade-off criteria and relative importance weights, the system conducts trade-offs of alternative allocation strategies based on the most effective, efficient, economical, and safe utilization of crew members, and provides guidelines on the strong and weak points of alternative allocation strategies. System geared toward space station EVA (Extra Vehicular Activity) and RMS (Remote Manipulator System) evaluation.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• NA, conceptual	• NA, conceptual	• Apple Macintosh Plus

CLASSIFICATION

PHASE CE

APPLICATION advanced **ACTIVITY** design, analysis

ROLE
- design and layout crewstations to support space station missions

TYPE expert system

CLASS
- FEA
- functional analysis
- task allocation
- crew station design

STATUS conceptual

COST Low

ADVANTAGES

- Functional allocation strategy based on system performance is in marked contrast to traditional functional allocation decisions which operate under an implicit strategy of automate whenever possible

DISADVANTAGES

NA, conceptual

SOURCE

Carlow Associates Incorporated
8315 Lee Highway, Suite 410
Fairfax, VA 22031

REFERENCES

Malone, 1986

COMMENTS

TOOL NAME: GEOMOD (Geometric Modeling Tool)

Aviation Related? yes **Record # 88**

DESCRIPTION

GEOMOD is a tool for developing workstations or cockpits around a man-model. The designer selects the percentile category of the potential users of the system, then begins to design around the man-model. To facilitate development of the system, the designer can view his drawing from any angle by rotating it. The program produces a 2-D blueprint sufficient for a draftsman to build from. Any system modifications can be done on the screen without incurring costs for prototype development.

REQUIREMENTS

INPUT REQUIREMENTS	OUTPUTS	RESOURCE REQUIREMENTS
• anthropometric percentile category of users • environmental characteristics (parameters of the cockpit as they are developed)	• reach assessments • fit assessments • obstruction assessment • 2-D blueprint ready for a draftsman to use for building the system	• Tektronics display (25" screen available) • HP 9000 • VAX

CLASSIFICATION

PHASE FSD, D&V

APPLICATION advanced **ACTIVITY** design

ROLE
- development of aircraft cockpits, workstations, etc.

TYPE workspace model

CLASS
- workstation design
- reach analysis

STATUS operational

COST Moderate

ADVANTAGES

- 2-D blueprint for draftsman
- low training
- system modifications can be done on the screen

DISADVANTAGES

- none identified

SOURCE

Hughes Aircraft Co.
GSG, MS 618/M111
Box 3310
Fullerton, CA 92634

REFERENCES

Erlichman, 1987

COMMENTS

APPENDIX B

ADVANCED HUMAN FACTORS ENGINEERING TOOLS CLASSIFICATION

Advanced Human Factors Engineering Tools Classification

#	Tool Name	MAP Phase	HFE Activity	Tool Type	Tool Class	Priority	Cost
1	CRAFT	FSD	design	CAD	• panel design	26	MOD
2	WOLAP	FSD	design	CAD	• panel design	26	MOD
3	HECAD	FSD	design	CAD	• panel design	26	MOD
4	TEPPS	CE, D&V	analysis	functional model	• FEA • performance analysis • task modeling	20	HIGH
5	SAINT	CE, D&V, FSD	analysis, T&E	task model	• FEA • workload analysis • task modeling	12	HIGH
6	COMBIMAN	FSD	design	graphic man-model	• workstation design	18	HIGH
7	SIMWAM	D&V, FSD, PI, CE, Pre-Con, P&D	analysis, T&E	task model	• workload analysis • T&E • FEA	1	LOW
8	ORACLE	D&V, FSD	analysis	info flow model	• workload analysis • task analysis	28	HIGH

Advanced Human Factors Engineering Tools Classification

#	Tool Name	MAP Phase	HFE Activity	Tool Type	Tool Class	Priority	Cost
9	TREES	FSD	design	data access	• procedures • maintenance	26	MOD
10	TX-105	FSD	analysis	workspace model	• workload analysis	18	MOD
11	TLA-1	FSD	analysis	task model	• workload analysis • FEA • task modeling	20	HIGH
12	SAMMIE	D&V, FSD	design, evaluation	workspace model	• workspace design • workplace design • reach • vision	18	HIGH
13	CAPABLE	FSD	design	graphic	• panel design	28	HIGH
14	Micro SAINT	Pre-con, CE, D&V, FSD, P&D, PI	analysis	task model	• workload analysis • FEA • task modeling	1	MOD
15	FLAIR	FSD	design	rapid prototyping	UCI Design	28	HIGH
16	LAYGEN	FSD	design	graphic	• panel design	12	HIGH

Advanced Human Factors Engineering Tools Classification

#	Tool Name	MAP Phase	HFE Activity	Tool Type	Tool Class	Priority	Cost
17	STELLA	Pre-con, CE, D&V, FSD, P&D, PI	analysis	functional model	• FEA	25	MOD
18	ADM	D&V, FSD	design	user interface management system	• UCI design	30	HIGH
19	COUSIN	FSD	design	UIMS	• UCI design	28	MOD
20	CORELAP	FSD	design	graphic	• workspace layout • facility design	28	HIGH
21	CAPE	FSD	T&E	graphic	• workstation	18	LOW
22	TASCO	FSD	design	timeline, task model	• performance analysis • T&E	18	HIGH
23	ERGONOGRAPHY	FSD	design	graphics	• facility design	0	NA
24	MENULAY	FSD	design	rapid prototyping	• UCI design • rapid prototyping	26	MOD

Advanced Human Factors Engineering Tools Classification

#	Tool Name	MAP Phase	HFE Activity	Tool Type	Tool Class	Priority	Cost
25	ASSET	Pre-con, CE, D&V	analysis	logistic model	• comparability • FEA • TA • Maintenance	28	MOD
26	DAP	D&V, FSD, PI,	T&E	rapid prototyping	• display evaluation • UCI design	9	MOD
27	SIEGEL-WOLF	D&V, FSD	analysis	task model, workload	• performance analysis	18	HIGH
28	CGE/BOEMAN	FSD	design, T&E	man-model, graphic	• reach • vision • panel design • workstation	18	HIGH
29	HF-ROBOTEX	FSD	design	expert system	• robotics	1	LOW
30	GRASP	FSD	design	CAD	• robotics • reach	1	LOW
31	CADAM/ADAM & EVE	D&V, FSD	design	CAD, man-model	• workstation • reach	3	MOD
32	KADD	FSD	design	expert system	• display design	18	MOD

Advanced Human Factors Engineering Tools Classification

#	Tool Name	MAP Phase	HFE Activity	Tool Type	Tool Class	Priority	Cost
33	CAFES	CE, D&V, FSD	analysis, design	family of tools	• function allocation	20	HIGH
34	FAM	CE, D&V, FSD	analysis	task model	• function allocation • functional analysis • procedures design	28	HIGH
35	WAM	D&V, FSD	analysis	task model	• FEA • workload	20	HIGH
36	HOS	CE, D&V, FSD	analysis	man-model	• workload • performance analysis	20	HIGH
37	CAFES-CAD	FSD	design	CAD	• workstation design • panel design • reach analysis • vision analysis	28	HIGH
38	DMS	FSD	analysis	database	• data integration	26	HIGH
39	MAWADES	D&V, FSD	design	family of tools	• panel design • workspace layout • crew station design	12	HIGH
40	WOSTAS	FSD	analysis	task model	• task allocation • workload • procedures	2	MOD

Advanced Human Factors Engineering Tools Classification

#	Tool Name	MAP Phase	HFE Activity	Tool Type	Tool Class	Priority	Cost
41	WORG	FSD	design	graphic	• workstation arrangements • facility design	2	MOD
42	WOLAG	FSD	design	graphic	• panel design • reach • vision	10	HIGH
43	OSDS	CE, D&V	design	graphic	• panel design • reach • vision	2	HIGH
44	PLAID	FSD	design	CAD	• panel design • reach • vision	26	MOD
45	CADET	D&V, FSD	design, T&E	CAD	• panel design • reach/vision • workload • simulation	20	HIGH
46	CAR	FSD	CAD	man-model, workspace model	• reach evaluation • panel design	1	MOD
47	CHESS	FSD	design	workstation model	• workstation design	0	NA
48	SWAT	FSD	T&E	rating scale	• workload evaluation	20	MOD

Advanced Human Factors Engineering Tools Classification

#	Tool Name	MAP Phase	HFE Activity	Tool Type	Tool Class	Priority	Cost
49	OWLES	FSD	T&E	information model	• workload evaluation	4	HIGH
50	ATB Model	D&V, FSD	design	graphic	• life support	20	HIGH
51	BIOMAN	D&V, FSD	design	man-model, workspace model, graphic	• panel evaluation • visual envelope	2	HIGH
52	BUFORD	FSD	design	man-model	• workstation desgin	0	NA
53	CALSPAN 3D CVS	FSD, P&D, PI	T&E	man-model, crash simulation	• life support	20	HIGH
54	CINCI KID	FSD, P&D, PI	T&E	man-model	• life support	18	MOD
55	COM-GEOM	FSD	design	man-model	• workstation design	18	MOD
56	CREW CHIEF	FSD	design	CAD, man-model	• maintenance design • reach • vision • workspace	18	MOD

Advanced Human Factors Engineering Tools Classification

#	Tool Name	MAP Phase	HFE Activity	Tool Type	Tool Class	Priority	Cost
57	CYBERMAN	D&V, FSD	design	man-model, crash simulation	• man-model • reach • vision • workspace layout	18	HIGH
58	ERGOMAN	FSD	T&E	man-model	• reach • vision	28	HIGH
59	GRAPHICAL MARIONETTE	FSD	design	man-model	• workstation design	18	MOD
60	HSRI Models	FSD	design	man-model, crash simulation	• life support	18	HIGH
61	NUDES	D&V, FSD	design	man-model, animated	• workstation design	20	MOD
62	SIMULA/PROMETHEUS	FSD	T&E	man-model, crash simulation	• life support	20	HIGH
63	SFU Model	D&V, FSD	design	man-model, animated	• workstation design	4	HIGH
64	STICKMAN	D&V, FSD	design	man-model	• workstation design	20	HIGH

Advanced Human Factors Engineering Tools Classification

#	Tool Name	MAP Phase	HFE Activity	Tool Type	Tool Class	Priority	Cost
65	TTI Models	D&V, FSD	design	man-model, crash simulation	• man-model • crash simulation	20	MOD
66	UCIN	D&V, FSD	design, T&E	man-model, crash simulation	• life support	28	HIGH
67	GENSAW	CE, D&V, FSD	analysis	family of tools	• FEA • task analysis	3	HIGH
68	CRAWL	Pre-Con, CE, D&V, FSD	analysis	task model, workload; task model, timeline	• workload analysis • T&E • FEA	1	NA
69	HIMS	D&V, FSD, P&D, PI	analysis	task model, performance	• performance analysis	3	NA
70	ZITA	CE, D&V, FSD	Analysis	task model, timeline; task model, performance	• performance analysis • workload analysis	1	LOW
71	SPRINGMAN	FSD	design	graphics man-model	• workstation design • reach/vision analysis	18	HIGH
72	SLAM II	Pre-con, CE, D&V	analysis, T&E	task model	• FEA • performance analysis • task modeling	4	HIGH

Advanced Human Factors Engineering Tools Classification

#	Tool Name	MAP Phase	HFE Activity	Tool Type	Tool Class	Priority	Cost
73	ETAS	CE, D&V, FSD	analysis	database	• training analysis	9	MOD
74	ICAM	Pre-con, CE, D&V, FSD	analysis	task model, workload; task model, timeline	• workload analysis • T&E • FEA	0	NA
75	BEMOD	FSD	analysis	task model	• task modeling • visual analysis • workload analysis • performance	30	MOD
76	CVAS	D&V, FSD	design, analysis	man-model, simulation	• crew station design	0	NA
77	CAPRA	FSD	design, T&E	reliability model	• maintenance analysis	3	MOD
78	TEMPUS	D&V, FSD	design	man-model, workspace model	• workstation design	0	HIGH
79	CUBITS	FSD	design	workspace model	• CD design • panel design	26	MOD
80	Designer's Associate	CE, D&V, FSD	design, T&E	expert system	• performance	0	NA

Advanced Human Factors Engineering Tools Classification

#	Tool Name	MAP Phase	HFE Activity	Tool Type	Tool Class	Priority	Cost
81	POSIT	FSD, D&V	design	man-model animation	• reach analysis	20	HIGH
82	Knowledge-based HFE Doc. Prep. Sys.	Pre-con, CE, D&V, FSD, P&D, PI	design, analysis, T&E	Data Access, expert system	• FEA • management • T&E	5	MOD
83	SIMKIT	Pre-con, CE	analysis	expert system	• simulation	12	HIGH
84	DART	Pre-Con, CE, D&V, FSD	analysis	task model, workload, task model, timeline	• workload analysis • T&E • FEA	1	MOD
85	PROFILE	D&V	design	expert system	• maintenance analysis	11	HIGH
86	MOPSIE	D&V, FSD	analysis	information model	• workload analysis • evaluation	20	HIGH
87	Fct. Allocation Decision Aid	CE	design, analysis	expert system	• FEA • functional analysis • task allocation • crew station design	0	NA
88	GEOMOD	FSD, D&V	design	workspace model	• workstation design • reach analysis	2	MOD

APPENDIX C

ADVANCED HUMAN FACTORS ENGINEERING TOOLS COST ASSESSMENT

Advanced Human Factors Engineering Tools Cost Assessment

#	Tool Name	Acquisition Cost	Setup Cost	Training Cost	Resource Cost	Overall Cost
1	CRAFT	NONE	MOD	LOW	HIGH	MOD
2	WOLAP	MOD	HIGH	LOW	HIGH	MOD
3	HECAD	NONE	MOD	LOW	HIGH	MOD
4	TEPPS	NONE	HIGH	HIGH	HIGH	HIGH
5	SAINT	NONE	HIGH	HIGH	HIGH	HIGH
6	COMBIMAN	NONE	MOD	LOW	HIGH	HIGH
7	SIMWAM	NONE	HIGH	LOW	LOW	LOW
8	ORACLE	HIGH	HIGH	HIGH	HIGH	HIGH
9	TREES	MOD	LOW	LOW	HIGH	MOD
10	TX-105	HIGH	MOD	LOW	HIGH	MOD
11	TLA-1	NONE	HIGH	HIGH	HIGH	HIGH
12	SAMMIE	$90-510K	HIGH	LOW	HIGH	HIGH
13	CAPABLE	MOD	MOD	HIGH	HIGH	HIGH
14	Micro SAINT	HIGH	HIGH	LOW	LOW	MOD
15	FLAIR	HIGH	MOD	HIGH	HIGH	HIGH

Advanced Human Factors Engineering Tools Cost Assessment

#	Tool Name	Acquisition Cost	Setup Cost	Training Cost	Resource Cost	Overall Cost
16	LAYGEN	MOD	MOD	HIGH	HIGH	HIGH
17	STELLA	$200	HIGH	LOW	LOW	MOD
18	ADM	HIGH	HIGH	LOW	HIGH	HIGH
19	COUSIN	NONE	MOD	LOW	HIGH	MOD
20	CORELAP	HIGH	HIGH	HIGH	HIGH	HIGH
21	CAPE	NONE	LOW	LOW	HIGH	LOW
22	TASCO	NONE	HIGH	LOW	HIGH	HIGH
23	ERGONOGRAPHY	PROP	NA	NA	NA	NA
24	MENULAY	MOD	MOD	LOW	HIGH	MOD
25	ASSET	NONE	HIGH	HIGH	HIGH	MOD
26	DAP	$99	MOD	LOW	LOW	MOD
27	SIEGEL-WOLF	NONE	HIGH	HIGH	HIGH	HIGH
28	CGE/BOEMAN	NONE	HIGH	LOW	HIGH	HIGH
29	HF-ROBOTEX	NONE	MOD	LOW	LOW	LOW
30	GRASP	MOD	MOD	LOW	LOW	LOW

Advanced Human Factors Engineering Tools Cost Assessment

#	Tool Name	Acquisition Cost	Setup Cost	Training Cost	Resource Cost	Overall Cost
31	CADAM/ADAM & EVE	HIGH	MOD	HIGH	LOW	MOD
32	KADD	LOW	HIGH	LOW	HIGH	MOD
33	CAFES	NONE	HIGH	HIGH	HIGH	HIGH
34	FAM	NONE	HIGH	HIGH	HIGH	HIGH
35	WAM	NONE	HIGH	HIGH	HIGH	HIGH
36	HOS	NONE	HIGH	HIGH	HIGH	HIGH
37	CAFES-CAD	NONE	HIGH	HIGH	HIGH	HIGH
38	DMS	NONE	MOD	LOW	HIGH	HIGH
39	MAWADES	NONE	HIGH	HIGH	HIGH	HIGH
40	WOSTAS	NONE	HIGH	LOW	HIGH	MOD
41	WORG	NONE	HIGH	LOW	HIGH	MOD
42	WOLAG	NONE	HIGH	LOW	HIGH	HIGH
43	OSDS	NONE	MOD	LOW	HIGH	HIGH
44	PLAID	NONE	MOD	LOW	HIGH	MOD
45	CADET	NONE	HIGH	HIGH	HIGH	HIGH

Advanced Human Factors Engineering Tools Cost Assessment

#	Tool Name	Acquisition Cost	Setup Cost	Training Cost	Resource Cost	Overall Cost
46	CAR	NONE	LOW	LOW	HIGH	MOD
47	CHESS	PROP	NA	NA	NA	NA
48	SWAT	NONE	HIGH	HIGH	MOD	MOD
49	OWLES	NONE	HIGH	HIGH	HIGH	HIGH
50	ATB Model	NONE	HIGH	HIGH	HIGH	HIGH
51	BIOMAN	NONE	MOD	LOW	HIGH	HIGH
52	BUFORD	PROP	NA	NA	NA	NA
53	CALSPAN 3D CVS	NONE	MOD	HIGH	HIGH	HIGH
54	CINCI KID	MOD	MOD	LOW	MOD	MOD
55	COM-GEOM	NONE	MOD	LOW	HIGH	MOD
56	CREW CHIEF	NONE	MOD	LOW	HIGH	MOD
57	CYBERMAN	HIGH	HIGH	LOW	HIGH	HIGH
58	ERGOMAN	MOD	MOD	HIGH	HIGH	HIGH
59	GRAPHICAL MARIONETTE	MOD	MOD	LOW	HIGH	MOD
60	HSRI Models	NONE	HIGH	LOW	HIGH	HIGH

Advanced Human Factors Engineering Tools Cost Assessment

#	Tool Name	Acquisition Cost	Setup Cost	Training Cost	Resource Cost	Overall Cost
61	NUDES	MOD	MOD	LOW	HIGH	MOD
62	SIMULA/PROMETHEUS	HIGH	HIGH	HIGH	HIGH	HIGH
63	SFU Model	HIGH	HIGH	HIGH	LOW	HIGH
64	STICKMAN	NONE	HIGH	HIGH	HIGH	HIGH
65	TTI Models	NONE	MOD	HIGH	HIGH	MOD
66	UCIN	MOD	HIGH	HIGH	HIGH	HIGH
67	GENSAW	NONE	HIGH	HIGH	HIGH	HIGH
68	CRAWL	PROP	NA	NA	NA	NA
69	HIMS	PROP	NA	NA	NA	NA
70	ZITA	$15K	LOW	LOW	LOW	LOW
71	SPRINGMAN	HIGH	HIGH	LOW	HIGH	HIGH
72	SLAM II	$10K	HIGH	HIGH	LOW	HIGH
73	ETAS	$15K	HIGH	LOW	LOW	MOD
74	ICAM	CNPT	NA	NA	NA	NA
75	BEMOD	NONE	HIGH	LOW	HIGH	MOD

Advanced Human Factors Engineering Tools Cost Assessment

#	Tool Name	Acquisition Cost	Setup Cost	Training Cost	Resource Cost	Overall Cost
76	CVAS	PROP	NA	NA	NA	NA
77	CAPRA	HIGH	MOD	HIGH	LOW	MOD
78	TEMPUS	$50K Min.	MOD	NA	NA	HIGH
79	CUBITS	NONE	LOW	LOW	HIGH	MOD
80	Designer's Associate	CNPT	NA	NA	NA	NA
81	POSIT	MOD	HIGH	HIGH	HIGH	HIGH
82	Knowledge-based HFE Doc. Prep. Sys.	NONE	HIGH	LOW	LOW	MOD
83	SIMKIT	HIGH	LOW	HIGH	HIGH	HIGH
84	DART	$18K	MOD	LOW	LOW	MOD
85	PROFILE	$7K	HIGH	HIGH	HIGH	HIGH
86	MOPSIE	HIGH	MOD	HIGH	HIGH	HIGH
87	Fct. Allocation Decision Aid	CNPT	NA	NA	NA	NA
88	GEOMOD	HIGH	MOD	LOW	HIGH	MOD

APPENDIX D

ADVANCED HUMAN FACTORS ENGINEERING TOOLS DATA BASE USER'S GUIDE

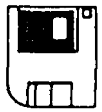
TABLE OF CONTENTS

Section 1. INTRODUCTION

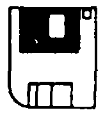
Equipment

To operate the Advanced HFE Tools Data Base, you will need an Enhanced Macintosh or Mac Plus with 512 Kb of RAM and two 800 Kb disk drives.

The Advanced HFE Tools Data Base was created on the Double Helix program by Odesta; therefore, a copy of Double Helix is required to run this data base as well!

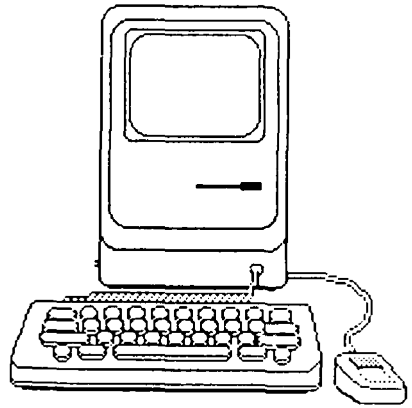


Advanced HFE Tools Data Base



Double Helix by Odesta

The User's Guide was developed to help users quickly master the Advanced HFE Tools Data Base. For more information than is included in this overview, refer to the Odesta Double Helix User's Guide.



Data Base Contents

The advanced tools data base management system (DBMS) provides an efficient means of searching for and retrieving information. Benefits of dynamically storing the results of the tools survey in a structured DBMS is that it provides a mechanism for easy expansion. Updating the final product as new tools hit the market or as additional information is received will be much simpler, and therefore more likely to be done. Additionally, users will be more likely to take advantage of the data base if it represents an up-to-date reflection of the availability of state-of-the-art HF tools.

The taxonomy used in defining the advanced tools capabilities and limitations consists of 20 discrete fields of information. This section defines these fields. For more detailed information, refer to Section 2.3 of the Final Report.

Tool Name - The full name for the tool along with the more familiar acronym or abbreviation, where applicable.

Record No. - A unique numeric identifier used to facilitate the retrieval of a specific tool.

Description - A narrative description of the tool synthesized from information obtained during the literature review, practitioner survey, and followup survey.

Input Requirements - Those features which must be known or identified before the tool can be used effectively.

Output Requirements - The expected results from a successful run or application of the tool.

Resource Requirements - The hardware and/or software required in order to use the tool.

Advantages - Strengths or positive features of a tool which facilitate its application or maximize its utility.

Disadvantages - Drawbacks or negative aspects of a tool which thwart its potential.

MAP Phase - Phase(s) of the materiel acquisition process in which the tool can be used or is typically used to derive its maximum effectiveness. These phases include:

- Preconceptual (PRE-CON)
- Concept Exploration (CON)
- Demonstration and Validation (D&V)
- Full Scale Development (FSD)
- Production and Deployment (P&D)
- Product Improvement (PI).

Data Base Contents (cont.)

Activity - The human factors engineering activity area under which the tool falls. Activity areas include:

- Design
- Analysis
- T&E.

Tool Type - The application area under which the tool falls, e.g., task models, man models, task analysis and rapid prototyping.

Tool Class - The specific HFE classification under its general area of application. Tool class may be viewed as a subset of tool type, and may include a combination of the classes. Examples of tool classes include panel design/evaluation, front end analysis, workspace layout or crew station design.

Role - Presents examples of how the tool has been used or how it can be used within an HFE context. Should be considered a combination of tool type and class.

Application - The tools orientation, that is, its role as being either a traditional tool with a *manual*, *generic* or data bent, or an advanced tool running on a main frame, mini-computer, or desk top microcomputer. For this phase of the contract, all tools included in the DBMS are advanced applications. This field has been added in anticipation of updating the system to include traditional HFE tools (e.g., hand held and generic proceduralized tools), and eventually tools which fall under other MANPRINT disciplines (i.e., HHA, MP&T, SS).

Status - Refers to the tools accessibility. Tool status is classified as being either Conceptual (not presently available for application), Protoype (available but does not include all planned features, or may not have been fully verified and/or validated e.g., tools in the beta stage of testing), or Operational (fully developed and available).

Cost - The absolute cost of the tool has been included if the information was available.

Aviation Related - Tools used specifically for aviation related work or which can be applied to aviation type problems have been identified as such.

Source - Identifies the tool developer, manufacturer or source from which the tool can be obtained.

References - Cites the reference material or personal conversations used in compiling information on the tool. Complete references can be found in the reports bibliography.

Comments - A catch all field designed to capture information which doesn't belong in any of the other fields. Designed primarily for users of the data base.

Definitions of Terms

All-Interactive. Menu selection which results in full access to all data collected for each advanced HFE tool.

All-Print. Menu selection which provides a ready made form for producing hard copies of the complete data set for each tool.

Click. To position the cursor over a particular object and quickly push and release the mouse button.

CON. Concept Exploration.

Cursor. Small shape on the screen which follows the cursor, generally an arrow, but will change to a clock or other design to signal the user to expect to wait.

DBMS. Data Base Management System.

Double Click. To position the cursor over a particular object and quickly push and release the mouse button twice in succession.

Dragging. Dragging is the act of moving a selected object across the screen while maintaining pressure on the mouse button.

D&V. Demonstration & Validation.

Field. A place holder for a certain piece of information within the record.

FSD. Full Scale Development.

HF. Human Factors.

HFE. Human Factors Engineering.

HHA. Health Hazard Assessment.

Highlight. Computer's response to user's selection of an object, usually by inverse video.

MAP. Materiel Acquisition Phase.

Mouse. Input device which rolls across a flat surface and facilitates input by selecting and dragging objects across a graphics interface screen.

MP&T. Manpower, Personnel & Training.

P&D. Production & Deployment.

PI. Product Improvement.

PRE-CON. Preconceptual.

Record. Collection of fields describing one item within the data base.

Search Menus. Menus which facilitate searches on areas considered to be of primary importance. These include: QUERY, MAP PHASE, and HFE ACTIVITY.

Select. Placing the cursor over the desired object and clicking the mouse button.

Scroll bar. The rectangular bar along the right and bottom of the display which allows the user to move the visible portion of the page either vertically or horizontally.

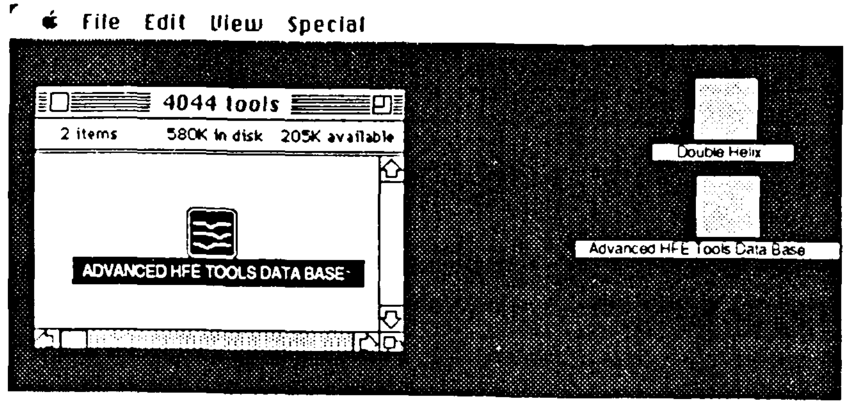
SS. System Safety.

T&E. Test & Evaluation.

Section 2. HOW TO USE THE DATA BASE

Getting Started

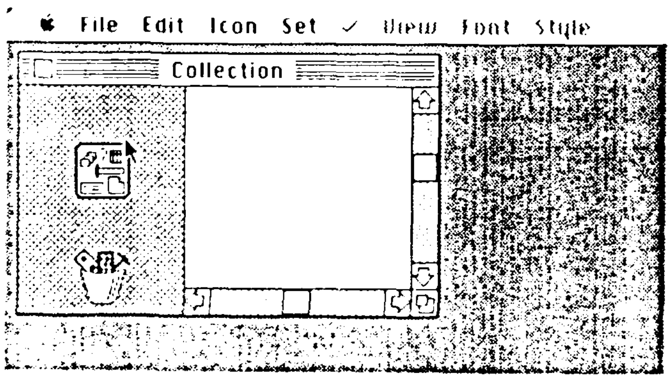
First, insert system disk, then the data base disk into the disk drives. The Macintosh "welcome" screen will be briefly presented before you are presented with the desktop similar to the one pictured at right.

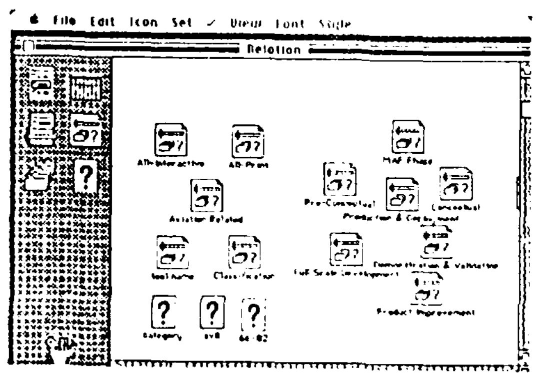


The data base is located on a disk labeled "Advanced HFE Tools Data Base". Double click on that disk to open it.

Double click on the icon labeled "Advanced HFE Tools Data Base".

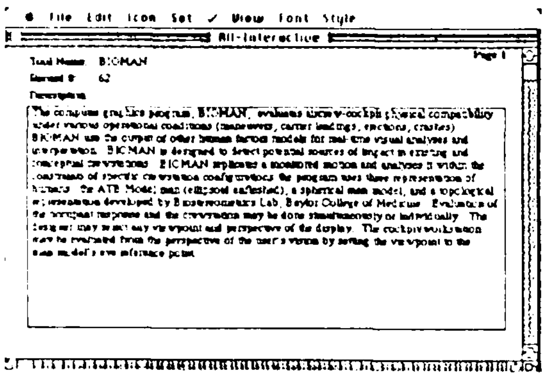
Because the data base always opens to the place where it was last closed, you may have to find the "All-Interactive" mode from one of several locations. Example screens are pictured below. From the location portrayed in the left-hand screen, first select "Close," then "Open" from the FILE menu. A box will appear allowing you to open the file named "Advanced HFE Tools Data Base." Click the button labeled "Open." At any point within the data base, you may select the "Custom Mode" option from the SET menu to access the Search Menus. Both of the "All-Interactive" and "All-Print" modes are then available under the QUERY menu.



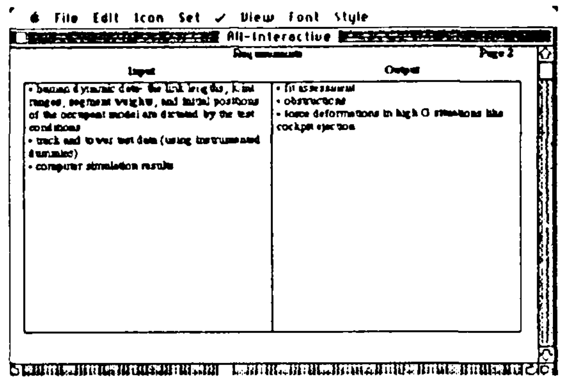


Accessing the Interactive Data Base

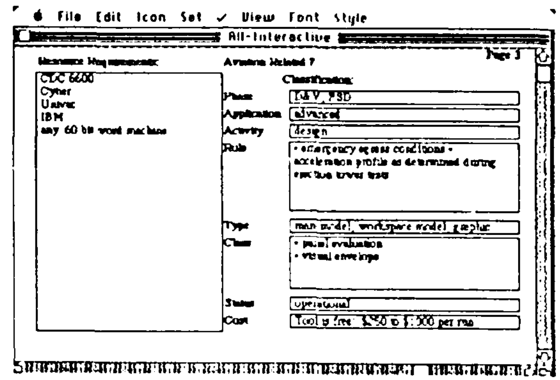
To page through the complete set of data available for each of the advanced HFE tools, you must use the scroll bars on the bottom and side of the screen. The pages are laid out on a large area, much as they are pictured below. To move from one page to another, simply click to that side of the appropriate scroll bar. For example, to move from Page 1 to Page 2, click to the right of the white marker on the bottom scroll bar. To move from Page 1 to Page 4, click below the white marker on the scroll bar to the right of your screen.



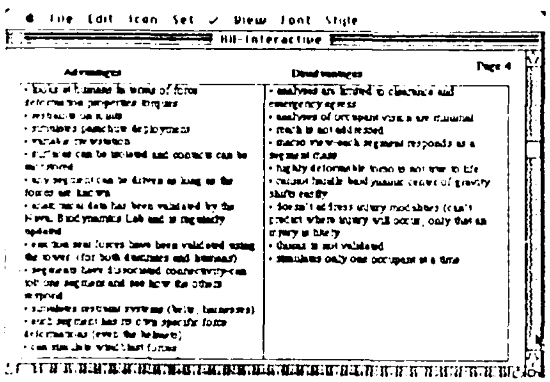
To get to page 1 from any other page, set the white markers to the furthest up and left positions.



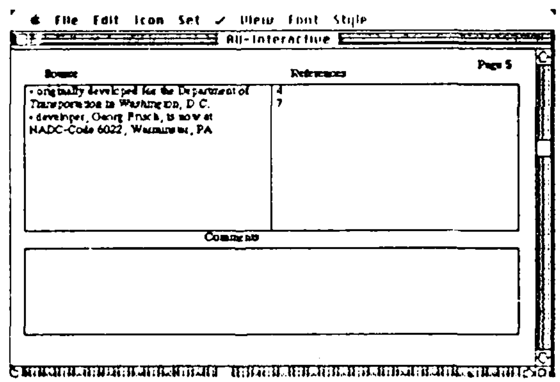
Click to the right of the white marker on the bottom scroll bar to get to Page 2.



Click to the right of the white marker again to get to Page 3.



From Page 3, click twice to the left of the bottom scroll bar to return to Page 1, then click once below the white marker on the right-hand scroll bar to reach Page 4.



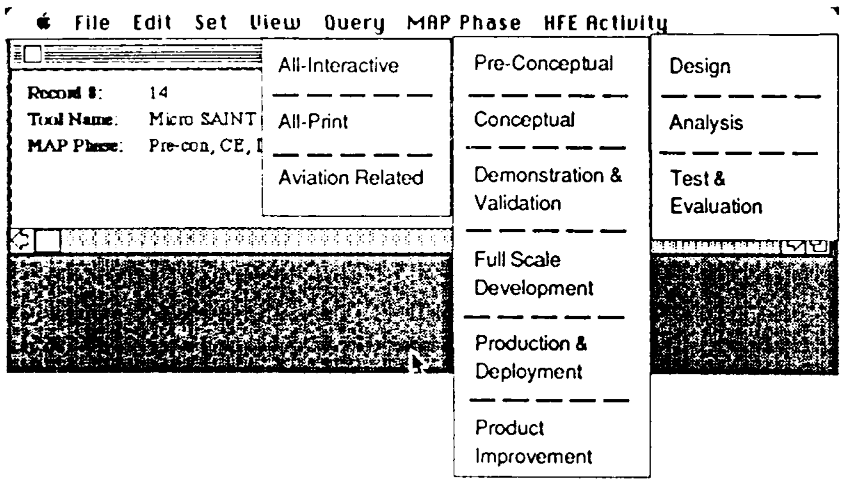
Click once to the right of the white marker on the bottom scroll bar to access page 5. Reverse these directions to return to other pages.

The Search Menus are available while working in the interactive screens. Simply select "Custom Mode" from the SET menu to activate the Search Menus. Then, select "All-Interactive" from the QUERY menu to re-access the interactive screens.

Using the Search Menus

Search menus facilitate searches on those areas considered to be of primary importance. These areas include the six phases of the materiel acquisition process, the three HFE activity areas, and those tools related to aviation.

To access the custom menus, pull down the menu under SET and select Custom Mode. The screen will clear, and the menu bar will include the custom menus: QUERY, MAP PHASE, and HFE ACTIVITY. Pull down these menus to select your choice of search terms.

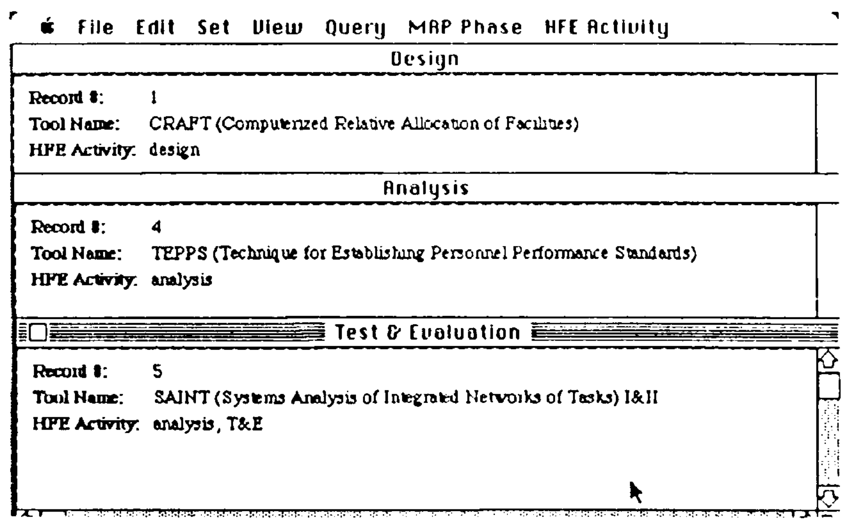


This is an illustration of the contents of the pull-down search menus, the query menu (which contains choices about which full-data mode you wish to access and the search term for the aviation related tools), and an example of one abbreviated search form.

Data briefly describing the Advanced HFE Tools will be presented on abbreviated forms. More than one of these forms will fit on the screen, although they may overlap.

If you are presented with a blank form, you will initially need to "Find First", or call up the first record in that file, then you may access the rest with the following commands: "Find Next", "Find Previous", and "Find Last". The data will be presented to you one record at a time as you request. These commands are located under the VIEW menu and can be accessed via the mouse or with the following keyboard commands:

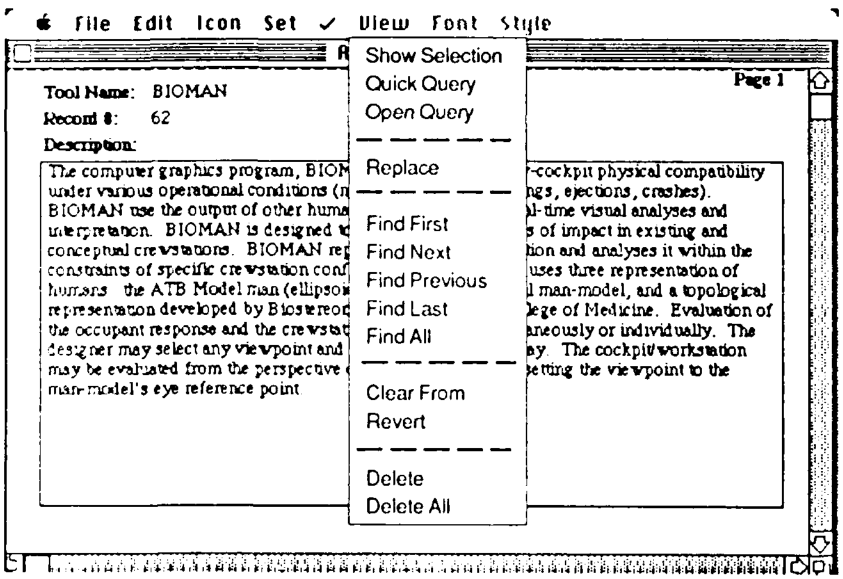
Find First	⌘ Q	Find Previous	⌘ E
Find Next	⌘ W	Find Last	⌘ R



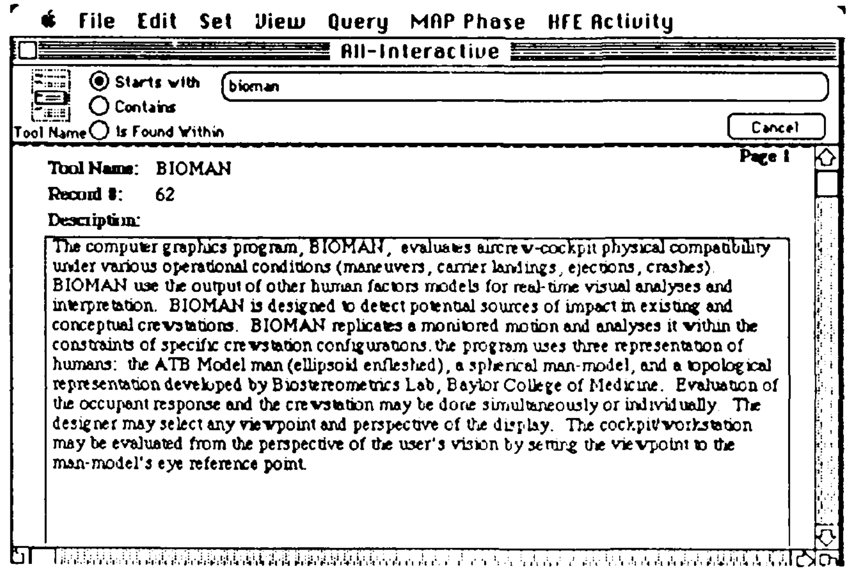
All three menu selections from HFE ACTIVITY may be viewed on the screen at one time. Selections from other menus may overlap.

Using the Quick Query Function

All of the categorization fields and categorization levels may be used singularly or in combination to query a specific area of interest associated with advanced tool use. For example, all man model or workspace layout related tools may be identified quickly by using the Query functions for Tool Type and Tool Class, respectively. One query method, "Quick Query", will be described in this section; other, more complicated and powerful methods may be obtained from the Double Helix User's Guide by Odesta.



To begin your query, select "Quick Query" from the VIEW menu. A query box will appear at the top of the screen directly under the menu bar. Quick Query may be used on any of the five pages within the Interactive Mode or while in the Search Menu Mode.



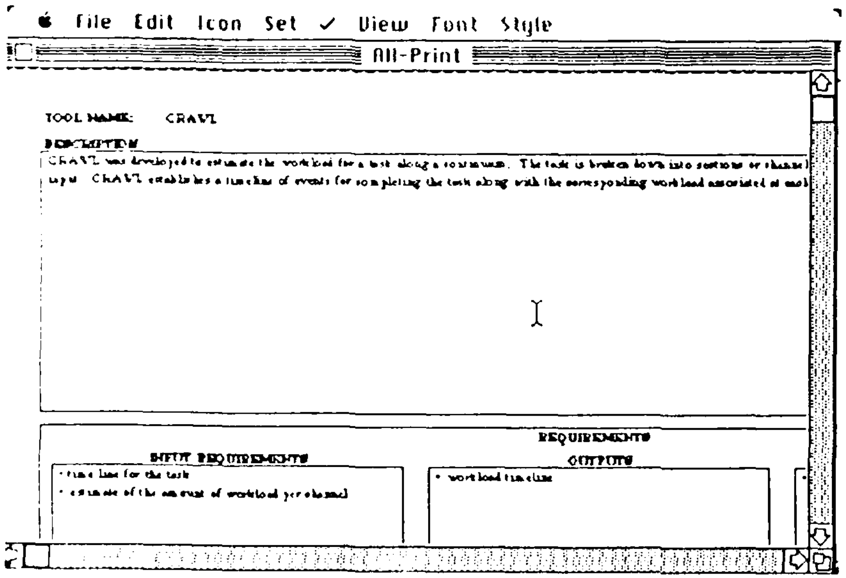
Place the cursor within the field you wish to search. Notice that the small field icon to the left of the quick query box changes to match the field you just selected.

Select one of the three search term options (i.e., "Starts with", "Contains", or "Is Found Within."), then enter the search term. Press Enter. The first record containing the data for that search term will appear in the form below. Other records corresponding to that search term can be accessed with the same commands found under the VIEW menu as described previously in the section titled "Using the Search Menus."

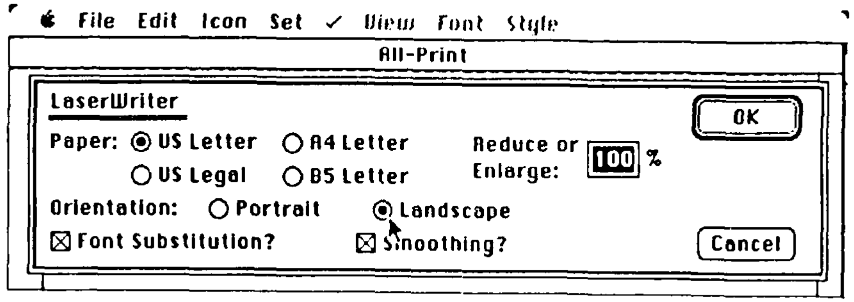
Printing Your Selections

Hard copies may be produced at any time using common Macintosh print functions. However, a form for printing the Advanced HFE Tool Data Base records has been designed and is the preferred format for producing hard copies of the data within this data base.

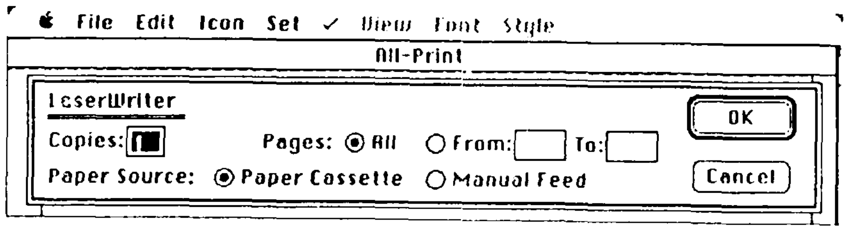
Select "All-Print" from the QUERY menu. The hard copy format will appear on the screen, as pictured below.



Select "Page Setup" from the FILE menu. You must set up the page before every print job, even if you have just completed a previous print job. Click on the "Landscape" option on the page setup box as pictured here (see example at top of next column).



Next, select either "Print Form" or "Print All" from the FILE menu. The regular Macintosh printing box will appear.



To print a single record, tab over to the boxes labeled "From" and "To" and enter the record number in both boxes, for example:

● From: 4 To: 4

To print consecutive records, enter the number of the first and last records in that group you wish to print. For example:

● From: 9 To: 15

Printing function will proceed consistent with Macintosh capabilities. See pages 9 and 10 for an example of the hard copy record forms for advanced HFE tools.

Section 3. TECHNICAL INFORMATION

This section is not intended to teach a novice user how to use a Macintosh or the Odesta Double Helix program, but to enable Advanced HFE Tools Data Base users to quickly master enough of both the system and the program to utilize this data base. More detailed information is available in your Macintosh User's Guide and your Odesta Double Helix User' Guide.

Menus

To access the pull-down menus, position the cursor over the menu title located on the menu bar across the top of the screen. Click and hold the mouse button. The contents of that menu will be displayed for as long as you depress the mouse button. To select an option, drag the cursor down the menu until the preferred option or command is highlighted (i.e., with inverse video). Release the mouse button and the menu will disappear while the system responds to your command. If you decide not to select an option from the menu, simply drag the cursor off the menu. Nothing is chosen unless you release the mouse button while one of the options or commands is highlighted.

Entering New Data

To enter a new record, first select "Find Last" from the VIEW menu, then select "Find Next". The screen will display a clear form for you to enter new advanced HFE tools to the data base.

The data base may also be updated with new information. Position the cursor anywhere within a field you wish to add information. The system will automatically place your typing at the beginning of that field. If there is already text in that field, then your new input will begin directly after it. Be sure to fill in every field of a new record and include the source (i.e., company or organization responsible for developing and/or marketing the tool) and references (i.e., articles from trade publications).

How to Quit

Select "Quit" from the FILE menu. The Double Helix program automatically saves newly entered data. NEVER turn off or unplug the computer to end a program session.

APPENDIX E

HUMAN FACTORS ENGINEERING
TOOLS QUESTIONNAIRE

INTRODUCTION

Carlow Associates Incorporated is under contract to the U.S. Army Human Engineering Laboratory (HEL) to identify tools which are currently used by human factors (HF) specialists in the daily conduct of their jobs. Anthropometers, task analysis, sound pressure level meters, and link analysis are just a few of the typical tools which are used by the human factors researcher. Outside of these mainstream, manual, or *traditional tools* generally associated with human factors engineering are tools which do not readily elicit recognition due to their novelty or general lack of citation in the human factors literature. For example, SAINT, CAFES, SAMMIE, and COMBIMAN are several automated or computerized aids which have been introduced in recent years. Unfortunately, the application and utility of these alternative, computerized or *advanced tools* by HF engineers have been largely unexplored.

The questionnaire which follows represents the first of several steps in the process of identifying HF tool requirements within the military, industrial, and government (MIG) setting, and comparing them to existing capabilities within the system acquisition process. The objective of this questionnaire is to identify the *traditional* and *advanced* human factors engineering tools which are presently used in laboratories and field settings throughout the MIG community, and to identify the capabilities of the advanced tools in replacing or augmenting the more traditional tools typically associated with human factors research. The goal at the conclusion of the study is to provide the Army with recommendations for an advanced tool set, along with a list of conceptual tools recommended for development based upon their potential for simplifying and expediting military development and operational test and evaluation.

You have been selected as a candidate for this study due to your unique qualifications for satisfying the selection criteria (i.e., currently managing or performing human factors research for the Department of Defense and/or having prior direct involvement in the development or testing of a human factors engineering tool). A positive response to this questionnaire is imperative in order to document existing HF technology shortfalls. As experts in the field of human factors engineering or tool development, your knowledge and opinions are considered valuable contributions to the overall tool identification effort. Please answer all of the questions as completely as possible. Additional instructions follow:

- Please complete the biographical information requested on the following page.
- Most of the questions will require a YES or NO answer, with some additional information. Please be as specific as possible with answers requiring explanatory information.
- When you have comments or suggestions, use the space provided below each question. If you need additional room, use the backs of the sheets.
- If possible, all questionnaires should be completed within five working days of initial receipt.
- For your convenience, an addressed and stamped envelope has been included with the questionnaire.
- When you finish the questionnaire, simply place it in the envelope and drop it in the mail.
- Thank you for your cooperation; your efforts are greatly appreciated.

Respectfully,
CARLOW ASSOCIATES INCORPORATED

Thomas B. Malone

Thomas B. Malone, Ph.D.
Principal Investigator

BIOGRAPHICAL DATA SHEET

Name:________________________________

Organization (Company/Institution):____

Occupation (Profession):____

Current Position (Title):____

Major or specialities (e.g., psychology, business, engineering, etc.) listed in order of highest degree or most experience:

1.________________

2.________________

3.________________

1. Years of experience in present occupation?___________

2. Please select the sector in which you are currently employed.

   Private Industry_____
   Government_____
   Military_____

3. Please select the appropriate role(s) which best describe your current function.
   Management:
      Corporate_____
      Technical_____
      Other______________________________
   Consulting_____
   Education_____
   R&D_____
   T&E_____
   Other__________________________________

4. If your mailing address has changed or is incorrect, please provide an updated address below:

   Organization____

   Department________________________ Telephone: (___) ___ - ____

   Address____

   City______________________ State__________ Zip__________

QUESTIONNAIRE

1. Do you use human factors tools (e.g., task analysis, photometers, SAINT, etc.) in the performance of your job?

Note:
If no, then please proceed to question 12.

YES NO

2. Have you ever been involved in the development of human factors tools? YES NO

If yes, please list the names of the tools and provide a brief description of the tools' objectives.

3. In your use of tools, do you rely more on traditional/manual tools (e.g., task analysis, photometers) or on advanced, computerized tools (e.g., CAFES, SAINT)? Please circle one.

Traditional Advanced

Why?

4. Does your work involve the development or use of human factors tools within the aviation community?

YES NO

If no, then please proceed to question 9. If yes, then please list below, in *descending order of use or importance*, those human factors tools used most frequently or that are viewed as most important in the performance of your aviation related work.

Tool 1:

Tool 2:

Tool 3:

5. Please describe briefly the objective and primary applications for Tool 1.

____

____

____

____

6. For each of the tools listed in question 4, please identify the tool's utility as being either specific to aviation work or generalizable to applications other than aviation (circle one response for each tool).

Tool 1----------------	Aviation Specific	Generalizable
Tool 2----------------	Aviation Specific	Generalizable
Tool 3----------------	Aviation Specific	Generalizable

7. Are the requirements of your job satisfied by the capabilities offered or features available for the tools identified in question 4?

YES NO

If no, then please describe the limitations, drawbacks, problems and disadvantages associated with tool use.

Tool 1:____ ____

____

____

Tool 2:____

____

____

Tool 3: ____________________

____

____

8. What new tool would you like to see developed that would facilitate your aviation related work?

____

____

____

9. Please list below, in *descending order of use,* those human factors tools (other than those listed in questions 4 through 8) that are used most frequently or that are viewed as most important in the performance of your (non-aviation related) work.

Tool A: ____________________

Tool B: ____________________

Tool C: ____________________

10. Please describe briefly the objective and primary applications for Tool A.

____

____

____

____

11. Are the requirements of your job satisfied by the capabilities offered or features available for the tools identified in question 9?

YES NO

If no, then please describe the limitations, drawbacks, problems and disadvantages associated with tool use.

Tool A: ______________________________

____

____

Tool B: ______________________________

____

____

Tool C: ______________________________

____

____

12. Are you aware of any on-going program(s) to develop new tools which have the potential for use within the field of human factors engineering?

YES NO

If yes, please give the name of the tool, the manufacturer or agency for whom the tool is being developed, and a brief description of the tool.

____

____

____

____

13. Are you building or involved in the development of any new human factors tools?

YES NO

If yes, then please provide a brief description of the tool below. Include in your description the purpose for tool development, the input requirements or prerequisites necessary for tool use, and the output or expected results from application of the tool.

14. Do you feel there is a need within the human factors community for new, more advanced tools?

YES NO

If yes, please describe the type of tool or tools you would like to see developed.

15. Would you be interested in seeing more advanced tools developed for use on the desktop microcomputer?

YES NO

If yes, then please describe the type of application you would like to see developed.

16. Would you be interested in seeing any existing advanced tools modified for use on the desktop microcomputer?

YES NO

If yes, then please describe the application you would like to see modified.

APPENDIX F

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